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The Politics of International Standardization

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Abstract

International standards are vital yet often overlooked components of global cooperation; they provide the detailed and technical specifications that make cross-border coordination possible. However, being grounded in expertise, their perceived neutrality and objectivity can obscure the underlying political drivers that shape the standardization process. In this dissertation, I challenge the depoliticized view of standardization by investigating its inherently political nature, asking: *How are the political processes of legitimation and negotiation reflected in ISO's standardization processes?*

I focus on the International Organization for Standardization (ISO), one of the largest and most comprehensive standardization organizations in the world. The first article introduces a novel database on various aspects of ISO's standardization process. In the second article, I explore the legitimation strategies employed by ISO as it broadens its scope to include societal standards, arguing that democratic legitimation is increasingly essential for transnational private institutions more broadly. In the third article, I conceptualize standardization as a form of technology diffusion, showing that political, economic and strategic factors drive the standardization process at ISO, ultimately arguing that it can serve as a means of achieving technological sovereignty.

This dissertation makes contributions to at least four distinct strands of literature. First, it advances the field of standardization by introducing a new database and quantitative empirical analyses focused on international standardization. Second, it contributes to the literature on private transnational governance by using a theoretical framework developed in the context of international organizations to analyze these institutions, employing ISO as a case study to assess its applicability. Third, it contributes to the literature on the role of technology in international relations by arguing that international standardization represents a form of outward technology diffusion that can strengthen technological sovereignty.

Finally, this dissertation contributes to the literature on depoliticization. Institutions such as courts, central banks and various international organizations have historically been perceived as functioning behind a veil of technicality and expertise, distancing themselves from the political process. Similarly, standardization organizations are often viewed as highly technical entities. However, as numerous scholars have pointed out, these institutions are far from apolitical. This dissertation demonstrates that international standardization is influenced by the same negotiation dynamics and legitimacy claims that define many other political processes.

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And finally, thank you to Jonas, the best thing that came out of this PhD. Your steady presence, calm support and playful spirit have been paramount in helping me reach this point. Words cannot describe how fortunate I feel to have met you. Thank you for entering my life and for sharing this journey with me. Whatever the future holds, I look forward to experiencing it with you.

Solveig Bjørkholt
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List of Papers

Paper I

Bjørkholt, S. Presenting the StanDat Database on International Standards: Improving Data Accessibility on Marginal Topics. In: *Political Science Research and Methods*. (2025), pp. 1–19. DOI: https://doi.org/10.1017/psrm.2025.3.

Paper II

Bjørkholt, S. Legitimation Strategies of Transnational Private Institutions: Evidence from the International Organization for Standardization. *Submitted to The Review of International Organizations.*

Paper III

Bjørkholt, S. Geopolitics in International Standardization Negotiations: Outward Technology Diffusion and Technological Sovereignty.

Contents

List of Acronyms

- **ISO** - International Organization for Standardization
- **TMB** - Technical Management Board
- **TC** - Technical Committee
- **JTC** - Joint Technical Committee
- **SC** - (Technical) Sub-Committee
- **P-member** - Participating Member
- **O-member** - Observing Member
- **TPI** - Transnational Private Institution
- **SDO** - Standards Development Organization
- **NGO** - Non-Governmental Organization
- **IEC** - International Electrotechnical Commission
- **ITU** - International Telecommunication Union
- **IASB** - International Accounting Standards Board
- **CEN** - European Committee for Standardization
- **CENELEC** - European Committee for Electrotechnical Standardization
- **IEEE** - Institute of Electrical and Electronics Engineers
- **GRI** - Global Reporting Initiative
- **FSC** - Forest Stewardship Council
- **MSC** - Marine Stewardship Council
- **SAI** - Social Accountability International
- **ICANN** - Internet Corporation for Assigned Names and Numbers
- **WTO** - World Trade Organization
- **GATT** - General Agreement on Tariffs and Trade
- **TBT** - Technical Barriers to Trade (Agreement)
- **STS** - Science and Technology Studies
- **GPT** - General-Purpose Technology
- **ISO 9001** - Standard series on Quality Management and Quality Assurance
- **ISO 14001** - Standard series on Environmental Management
- **ISO 26000** - Standard series on Social Responsibility

Chapter 1

Introduction

> *"A world without standards would soon grind to a halt. Transport and trade would seize up. The Internet would simply not function. Hundreds of thousands of systems dependent on information and communication technologies would falter or fail — from government and banking to healthcare, air traffic control, emergency services, disaster relief and even international diplomacy. So many aspects of the modern world are heavily dependent on standards."*
>
> – The 38th World Standards Day

The announcement given at the World Standards Day in 2007 illustrates the invisible and crucial role standards play in the world. As regulatory tools that govern the nitty-gritty details of technological solutions and cooperation, they are often overlooked and taken for granted. However, standards have proliferated over the past years, and they are fundamental in global governance.

Take credit cards. Across the world, credit cards have the exact same dimensions down to the millimeter, making them fit into any ATM and payment machine. Now, imagine a world where this international standard did not exist. Travelers would find themselves juggling multiple cards of differing dimensions, each one suited to a specific region or machine. Banks and merchants would have to invest in a slew of card readers, each tailored to a different size. To accommodate this messy patchwork, producers of credit cards and transaction machines would have to support and maintain a diverse array of versions, driving up costs for all parties involved. Security, too, would suffer. The lack of uniformity would create loopholes and vulnerabilities, producing a fragmented financial oversight and diminished consumer protection. As such, the standards that quietly govern technical details can have profound, wide-ranging impacts.

Indeed, governance through standards works so smoothly that we often do not notice them, except when they are not there. In 1999 the NASA Mars Climate Orbiter was on a mission to measure the Martian weather patterns, climate and atmosphere. It had traversed space for almost ten months before it finally reached Mars, caught fire and burned to pieces. The mission failure was attributed to a simple but catastrophic error. When designing parts of the spacecraft operation, one team used imperial units (pound-seconds) while another used metric units (newton-seconds). This discrepancy resulted in the spacecraft's trajectory being miscalculated, causing it to enter Mars' atmosphere at a lower altitude than planned and disintegrate (Lloyd, 1999).

These examples show how international standards almost unnoticeably facilitate the infrastructure of the global economy and cross-border interactions. They are global regulations produced by experts through private institutions rather than governments. These experts operate through consensus, their standards are voluntary and their aim is to find and disseminate the best solution to technical problems (Murphy & Yates, 2019). Given this description, it might be tempting to label standard-setting as apolitical. However, despite their technical and expert-oriented origin, there are important political undertones to standardization, as this dissertation will highlight.

The standardization of the shipping containers provides an example of these political undertones. Before the 1950s, goods between ports were transported in breakbulk vessels, which carried cargo in crates and barrels. This mode of transport was dependent on the longshoremen who worked at the docks; they stored the cargo onto the ships in ways that prevented them from breaking, they repaired broken barrels and crates when the ships arrived in port, and they moved shiploads from the ship to transit shed for further transportation. The process of loading and unloading items from the ship could keep it docked for weeks of non-profitable time, and the wages of the longshoremen could consume up to half of the total expense of the ocean voyage (Levinson, 2016, pp. 25-27).

In the mid 1950s, however, the shipping container saw the light of day. This new invention held great potential for speeding up the shipping process, but it required large scale infrastructure adaption. Ports had to host designated container storage areas and fit cranes capable of lifting and stacking containers. They had to implement new logistical systems to manage the increased efficiency and volume of containerized cargo. Truckers and trains had to be built to transport containers. And this had to happen for every single port a containerized ship visited. This vision was significantly complicated by the fact that the first containers varied in size, so that one company's containers would not always fit another's ship, truck or train wagon. This meant that "[a]s containers became more common, each ship line would need its own dock and cranes in every port, no matter how small its business or infrequent its ship's visits, because other companies' equipment would not be able to handle its boxes" (Levinson, 2016, p. 171).

To prevent this hazard, organized actors started working on a standard. These negotiations were eventually brought to the International Organization for Standardization (ISO), where the Technical Committee 104 established three working groups and began the slow process of agreeing on compatible elements of the container such as its size, strength requirements and lifting standards. The final standards approved containers of 10, 20, 30 and 40 feet, none of them compatible with the initial 24 and 35 feet used by the original container companies, leading to substantial conversion costs for them. For the corner fittings, following hard disputes over patented rights, the ISO committee finally agreed on the American solution. However, it soon realized that

defining appearance was not the same as defining the loads and stresses the corner fittings should be able to withstand. Thus, in just over a year, the committee hastily approved a new standard which required "the thousands of boxes that had been built since ISO first approved corner fittings in 1965 [to have] new fittings welded into place, at a cost that reached into the millions of dollars" (Levinson, 2016, p. 193). Clearly, there are substantial costs and risks involved in standardization, and thus also strong interests.

Beyond the initial errors, the standardization process resulted in some container sizes that were uneconomic and later abandoned. No one would claim that the committee came up with an optimal result. However, the initial standards fueled the containerization of shipping, making leasing companies willing to invest large sums into the enterprise. It was "becoming possible to fill a container with freight in Kansas City with a high degree of confidence that almost any trucks, trains, ports, and ships would be able to move it smoothly all the way to Kuala Lumpur" (Levinson, 2016, p. 201).

Unsurprisingly, these changes carried significant ramifications for the dockworkers. One of the first changes happened to the Port of New York, which lost significant activity to the establishment of Port Newark and Port Elizabeth. Despite fierce battles from the Union, in Manhattan, longshore employment declined by 91 percent between 1963 and 1976 (Levinson, 2016, p. 129). Similarly dire consequences awaited New York's off-dock workers in transportation and distribution (Levinson, 2016, p. 131). Although the dockwork jobs eventually took on a different character and became a highly paid bluecollar occupation, the changes impacted at least a generation of traditional working men (Levinson, 2016, p. 168)[1]. The same can be said for the world factory that sprung out of containerization. By enabling global value chains, containerization has led to a redistribution of manufacturing and logistics jobs across regions, affecting employment patterns worldwide. Working class jobs have moved to regions with comparatively cheaper labor force, leaving cheap products but also low wages for unskilled labor in its wake (Levinson, 2016, pp. 2-5). None of this would have been possible without a standard on the size on containers.

1.1 Research question and argument

Standards are technical regulations, but they both influence and are influenced by the social world. In this dissertation, I argue that standardization processes are, despite their technical nature, ultimately political processes. The introductory chapter illustrates a few ways in which standardization can be political. For example, it can have redistributive implications by shifting the location of jobs. Economic implications are

[1] In the case of New York, union leaders were actually able to negotiate a rare deal in which employers that profited from automation had to share profits with those whose jobs were automated away (Levinson, 2016, p. 169). This was unfortunately not the case elsewhere.

almost inevitable as standards favor one solution over others, posing transaction costs for those who need to adapt to the new standard, such as container size. Furthermore, standards often reflect national interests, such as agreeing on an American solution rather than the British solution to corner fittings. On a higher level, standards set norms that impact global governance, such as favoring international trade, and these norms can certainly be contested, especially as standardization processes now include many more actors beyond the US and Europe[2].

These examples also illustrate the diverse interpretations of what it means for something to be political. Politics can be understood for example as government (Flinders & Buller, 2006), as conflict (Gheyle, 2019), or as a means of establishing rationality (Foster et al., 2015). While a comprehensive discussion of the concept of the political is beyond the scope of this dissertation, I adhere to the straightforward and frequently cited definition by Hay (2007, p. 79): "the capacity for agency and deliberation in situations of genuine collective or social choice", and argue that this definition emphasizes two central aspects: negotiation and legitimation.

Hay's definition implies that there is a variety of ways in which political issues can be integrated into our society, and, furthermore, that we can engage with how this integration should come about. Because it implies that we have various options and can engage in how to rank or choose between these options, it highlights how outcomes are subject to bargaining and negotiations. Furthermore, the definition brings the importance of legitimacy into the picture, because political issues that can be contested are not accepted uncritically. To ensure that decisions are accepted and followed, institutions rely on the legitimacy of their authority[3]. Thus, negotiation around, and legitimation of, decisions becomes important aspects of the political. Drawing this back to standardization, the research question sounds: *How are the political processes of legitimation and negotiation reflected in ISO's standardization processes?*

Arguing that standardization processes are political reflects similar arguments made regarding institutions typically perceived as depoliticized, including central banks (Bagchi, 2024), courts (Voeten, 2022), meritocratic bureaucracies (Hansen, 2024), and various international organizations (Petiteville, 2018). These actors depoliticize their decision-making by emphasizing expertise, reliance on technical solutions and claims to neutrality in political matters (Louis & Maertens, 2021), which enables them to avoid contestation around decisions[4]. As many scholars have pointed out, standardization is

[2]Standardization also has serious implications in terms of security, for example when ISO initially neglected to standardize the strength requirements of the corner fittings of containers, which could have led to serious accidents.

[3]While decisions can be be enforced through coercion or self-interest, these methods are not available to most international organization, which then rely on legitimacy to justify their decision-making (Tallberg & Zürn, 2019).

[4]Depoliticization is a contested concept that sometimes is understood to be state-centric and sometimes understood to be a wider societal development. Wood and Flinders (2014) offers a good overview of various understandings. Governmental depoliticization refers to

a typical case of depoliticization (V. Higgins & Larner, 2010; W. Higgins & Hallström, 2007; Loconto & Busch, 2010; Timmermans & Epstein, 2010). The very act of setting a standard implies that experts have found the best solution to a technical problem, and thus no more contestation is warranted.

However, presenting decision-making as depoliticized does not relieve it of its inherent political drivers and implications (Flinders & Buller, 2006; Flinders & Wood, 2015; Krippner, 2012). For instance, the econometric models that central bankers use to establish monetary policy inherently produce a range of implicit winners and losers (Adolph, 2018; Best, 2018). Likewise, research has shown that judges' personal preferences and political orientations can significantly influence their legal interpretations and judgments (Bonica & Sen, 2021; Engst et al., 2024). In a similar vein, I argue that although standardization processes may be perceived as depoliticized by many audiences, they are subject to agenda-driven negotiations and dependent on being perceived as legitimate, making them inherently political. While this argument is not new, it has not been investigated systematically for various understandings of the political, and due to lack of data, quantitative studies assessing broader tendencies have been few and far between.

1.2 Scope and definitions

Before delving into the politics of standardization, this section defines core concepts and clarifies scope limitations in the dissertation. First, the word "standard" may invoke several connotations, for example standards of living, grading standards, double standards, human rights standards or moral standards. This dissertation focuses on standards as explicit regulatory tools; they are documents that specify a product or a process. Yet, even this delimitation leaves an incredibly broad research field.

The study of standards and standardization is highly interdisciplinary, including technical disciplines such as IT and engineering and social science disciplines such as economy and sociology (Grillo et al., 2024); it pertains to multiple levels of governance, from local to international (Büthe & Mattli, 2010b); it is produced in various fashions, from committee-based to market- and government-based (Büthe & Mattli, 2010a); it covers a wide range of topics, from cork design to social responsibility (Timmermans & Epstein, 2010); it can be concerned with either the formation or the spread of standards (Botzem & Dobusch, 2012); and it is trans-disciplinary, involving researchers as well as practitioners (Blind, 2024). Due to this variation, this section introduces the dissertation's definition of standards.

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delegation of issues to arms-length bodies such as judicial structures or technocratic rule-based systems, societal depoliticization is a reduction in public engagement and social dynamism towards more individual response to collective social challenges, and discursive depoliticization refers to the use of language and ideas to mark specific issues as elements of fate.

Second, standards pose a specific form of governance. They are examples of what has been termed “private” or ”hybrid“ regulation (Graz, 2019). They are more explicit than regular norms, and, in contrast to governmental regulation, they are not mandatory by design (Büthe & Mattli, 2010b). Furthermore, when standards are designed across borders, they are transnational. Thus, standards as a tool of governance fall under the rubric of “transnational private governance”, a concept that is also introduced in this section.

Last, this section introduces the International Organization for Standardization (ISO). The research contained in this dissertation relies heavily on data from the ISO, which therefore largely shapes the scope of the dissertation. In brief, it centers the research around international standards and confines it to committee-based standardization, as this is the ISO’s mode of operating. Focusing on ISO allows for the inclusion of a broad set of standardization topics, because ISO has an incredibly wide scope as an international standard-setter (Heires, 2008). Because ISO is a standard producer, this dissertation is also more oriented around the production of standards than their adoption. Furthermore, although I draw on literature from several research fields and informally on conversations and interviews with standard-setting practitioners, the research questions of this dissertation are anchored in political science and in academia more generally.

Standards

To understand how standardization can become political, one needs to understand what a standard is. Finding one definition is, however, complicated by the fact that standardization research is highly interdisciplinary and can therefore be understood in multiple ways depending on the research focus (Grillo et al., 2024). For example, sociological research has defined standardization as “a process of constructing uniformities across time and space, through the generation of agreed-upon rules” (Timmermans & Epstein, 2010, p. 71). Research by economists defines standards as “shared rules for designing or measuring products and processes” (Blind et al., 2023, p. 1). The International Organization for Standardization (ISO) defines a standard as “a formula describing the best way to do something”, while in science and technology studies (STS), standardization has been defined as a “process by which the form or function of a particular artifact or technique comes to be specified” (Feng, 2003).

Clearly, the various definitions of standards and standardization highlight the aim of standards to foster compatibility and harmonization. However, as Feng (2003) notes, there are many possible motivations for standardization, for example (1) uniformity in production, (2) compatibility between technologies, (3) objectivity in measurement, (4) as a means for justice to ensure equal treatment and (5) as a form of hegemony by promoting one solution over others. Given my focus on the

political dimension of standardization, a definition should include not only the aim of harmonizing technological solutions highlighted in many previous definitions, and in Feng's point 1, 2 and 3, but also the possibility of contestation that gives rise to negotiation and legitimation, that is, Feng's point 4 and 5. Thus, I construct a definition that incorporates not only standardization's harmonizing aim, but also its governance and distributive potential.

Synthesizing three different definitions, I define standards as "rules for common and voluntary use that structure interaction and represent values against which people, practices and things are measured" [5] This definition acknowledges that standards enhance compatibility by structuring interactions, while also highlighting that they are conceived of as rules which are in principle voluntary. The definition also highlights how standards can produce power by establishing norms for what is a "good solution".

Transnational private governance

Governance is a vague concept that lacks a clear definition (Offe, 2009), and it appears to be prone to conceptual stretching. For example, Fukuyama (2013, p. 350) defined governance as "the government's ability to make and enforce rules, and to deliver services", but upon acknowledging that governance may occur outside the state apparatus as well, expanded the understanding to encompass "a whole range of activities that have in common the act of steering or regulating social behavior" (Fukuyama, 2016, p. 90). It is in the latter definition that we find transnational governance, being an example of governance beyond the state.

Transnational governance can be contrasted with intergovernmental governance, which refers to regulatory cooperation among states, for example through the United Nations or the World Trade Organization. While they are both forms of global governance, transnational governance refers to non-state cooperation, and can be defined as "processes in which nonstate actors adopt rules that seek to move behavior toward a shared, public goal in at least two states" (Roger & Dauvergne, 2016, p. 416). In other words, private actors self-organize to create rules, for example to correct market failures (Mattli & Büthe, 2003). These rules include standards, but also other types of rules such as certification systems, codes of conduct, reporting guidelines and eco-labels (P. H. Pattberg, 2005).

Transnational governance occurs through transnational private institutions (TPIs). These institutions have, since the 1990s, grown to compose a significant portion of actors engaged in global governance (Bartley, 2022; Büthe & Mattli, 2011). TPIs are a diverse group that organize a large section non-state actors such as firms, non-governmental

[5]These definitions are drawn from various sources, respectively "rules for common and voluntary use" (Brunsson et al., 2012, p. 616), that "structure interaction" (Botzem & Dobusch, 2012, p. 739) and "represent values against which people, practices and things are measured" (Loconto & Busch, 2010, p. 526) (who again draws on Busch and Bingen (2006)).

organizations (NGOs) and professional societies. TPIs are sometimes referred to as "hybrid" when states are involved, in which case these states usually play a limited role (Auld et al., 2015). While there is no single agreed-upon definition of a TPI, according to P. Pattberg (2004, p. 55), TPIs are characterized by informal collaborations, an emphasis on rule-making, a diverse array of actors within networked constellations, and a commitment to uniting the profit and non-profit sectors to collectively uphold global public goods. Risse et al. (2006) ascribes two features to TPIs: the integration of non-state actors or NGOs in governance structures, and a preference for non-hierarchical methods of coordination.

Examples of transnational private institutions (TPIs) include the Forest Stewardship Council (FSC), the Global Reporting Initiative (GRI), Social Accountability International (SAI) and the Internet Corporation for Assigned Names and Numbers (ICANN). The major international standardization organizations are also part of the transnational private governance regime, including the International Accounting Standards Board (IASB), the International Electrotechnical Commission (IEC) and, of course, the International Organization for Standardization (ISO).

In the literature on TPIs, two questions in particular are central. First, under which circumstances is governance through TPIs effective? On one hand, TPIs tend to have a functional scope and substantial expertise that enable them to act where governments may lack the expertise, resources or flexibility to deal with the given regulatory tasks (Büthe & Mattli, 2011, p. 5). In countries with poor governmental infrastructure, private initiatives can also pose realistic alternatives to enforce human rights, environmental initiatives and labor standards (Graz & Nölke, 2007). Yet, the voluntary nature of these regulations may limit their scope and effectiveness (Bartley, 2018). Additionally, critics argue that even when private actors do adopt rules made by TPIs, compliance could be mere "window dressing" to improve reputation and avoid legal liability without necessarily putting in the effort to make substantial changes (Locke, 2013).

The second question relates to the legitimacy of TPIs. TPIs are neither democratically nor legally accountable, and although they may organize a multitude of actors, these actors are ultimately not representative bodies (Graz & Nölke, 2007). This has led scholars to question the legitimacy of TPIs, specifically their democratic legitimacy (Dingwerth, 2007). Scholarship in this field is both concerned with the normative basis of TPIs' legitimacy, and whether TPIs are perceived as legitimate by their respective stakeholders (Bernstein, 2011). The second paper in this dissertation further explores the legitimation of TPIs.

The International Organization for Standardization (ISO)

The empirical analyses in this dissertation focus on standards set by the International Organization for Standardization (ISO)[6]. This is one of the major international standardization organizations and the most diverse in terms of scope (Heires, 2008), making it the most widely recognized standard-setting body in the world (Koppell, 2011). ISO was formed between October 1945 and October 1946, but its predecessor, the International Federation of National Standardization Associations (ISA), dates back to 1926. However, where ISA never overcame the division between the "inch" and the "metric" countries, ISO has persevered and grown to become a large organization over the past decades (Murphy & Yates, 2009). From a small stock of 26 primarily European member bodies in 1947, ISO today hosts 172 full members. This expansion across continents can be seen in Figure 1.1.

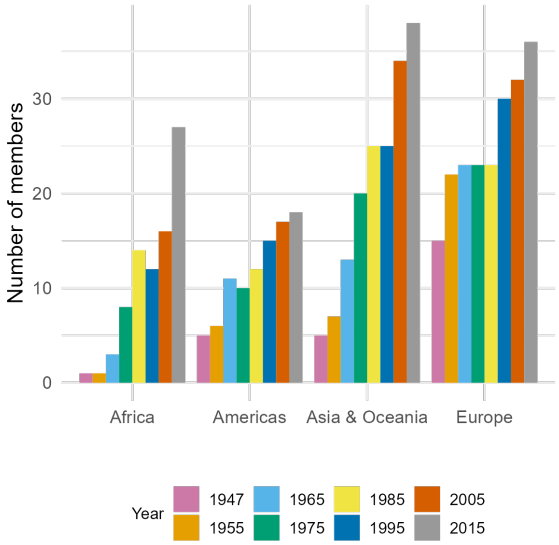

Figure 1.1: Growth in countries that are full members of ISO across continents, 1947 - 2015.

Populated by representatives from national standard bodies, ISO membership is open to all countries through their most representative standards body. These are, for

[6]Many people, myself included, have found the acronym ISO to be confusing. It would seem to translate to IOS if we take just the first letters of the International Organization for Standardization. However, adopting ISO as the acronym is a deliberate choice aimed at standardizing the term, ensuring it remains consistent regardless of the name used in various national languages. There is a common myth that the acronym derives from the Greek word "isos", meaning "equal". While this is a beautiful story, it has unfortunately been debunked by those involved in the organization's formation (Murphy & Yates, 2019).

example, the Deutsches Institut für Normung (DIN), the American National Standards Institute (ANSI) and Standard Norway (SN). Only a single body may represent a country in ISO, but they can send multiple experts. To date, more than 100,000 experts are involved in producing international standards ("ISO in Brief," 2019).

These experts are national representatives from various sectors such as industry, trade unions, professional associations, regulatory agencies and NGOs. This means that, in principle, given that a country has full ISO membership, any relevant member of an organization can reach out to their national standards body and request to participate in international standardization work, thus becoming an ISO expert. The caveat of full membership is necessary, because of all the ISO member categories – full member, correspondent member and subscriber member – only full members can actively engage in the standardization process, because only full members can propose new, and be participating members of, technical committees (TCs).

The actual work of standardization is carried out within the TCs. ISO as a whole is overseen by a council of rotating members, which receive information on the activity in the TCs. The council oversees the development of the multi-year strategic plan, annual budget, external relations, and other strategic decisions and operations of ISO. The council receives information from the Technical Management Board (TMB), which has significant agenda-setting power, as it decides which fields of standardization ISO should pursue (Murphy & Yates, 2009, p. 34).

Participating in the ISO Council, TMB or TCs are, however, all temporary positions. The only permanent staff of ISO are located in the Central Secretariat at Geneva. They count only about 150 people and coordinate the work happening in the TCs (Koppell, 2011). At the very top of the organizational structure is the General Assembly, which is the annual meeting of all ISO members, focusing on policy development, approval of the multi-year strategic plan, and financial matters. See Figure 1.2 for an organizational chart of ISO taken from their own website[7].

Due to this decentralized structure, ISO has been described as a "transnational private network of standards committees" (Heires, 2008, p. 358). Per 2025, ISO houses almost 850 TCs including their respective subcommittees (SCs), all covering various technical fields such as "Road vehicles" (TC 22), "Cultural heritage conservation" (TC 349) and "Quantum technologies" (JTC 3). The latter TC is an example of how ISO cooperates with other international standardization organizations. Through the Joint Technical Committees (JTCs), ISO cooperates with the International Electrotechnical Commission (IEC) and the International Telecommunication Union (ITU) when making standards on information technology.

[7]For clarity, the figure does not include advisory groups, policy development committees and other smaller units that report the the council beyond TMB and the Central Secretariat.

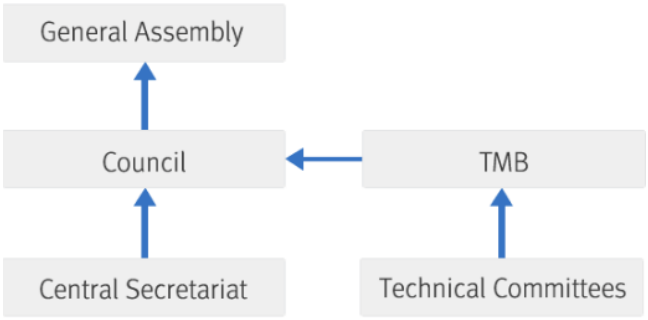

Figure 1.2: Governance structure and organizational chart at ISO.

In terms of international collaboration, international organizations can also participate in standardization work through being in liaison with relevant TCs. In 2020, the international organization being in liaison to most TCs was the European Commission (181), followed by the World Customs Organization (96) and the United Nations Economic Commission for Europe (73).

TCs such as TC 349 on "Cultural heritage conservation" and TC 309 on the "Governance of organizations" exemplify an expansion in ISO's work that has increased its international relevance in the last few decades. From focusing on technical topics such as shipping containers and road vehicles, ISO started in the 1980s to expand its work towards societal issue areas. This started with the publication of the 1987 Quality management standard series (ISO 9000), and continued with the Environmental management series (ISO 14000) in 1996 and Social responsibility in 2010 (ISO 26000) (Heires, 2008). These standards differ from the previous "physical" standards by not focusing on a single product, but on the complete process of an organization (Murphy & Yates, 2009; Ruwet, 2011). They regulate to improve aspects such as security, environmental footprint, equality and leadership. These societal issues have been more contested than the previous technical ones, further serving to show how standards can be political (Hahn & Weidtmann, 2016).

TCs are established when a national member body sends a proposal, often requested by representatives from national organizations, which is then circulated among the ISO members. At least five other member bodies have to vote in favor for the TC to be established. Those in favor take the role of participating members (P-members), and usually, the country responsible for the proposal takes the leadership of the TC, i.e. the secretariat. Sometimes, standard proposals are interlinked under existing TCs

into subcommittees (SCs) or working groups (WGs), as for example when Norway's "Diversity Management Systems" standard was approved as a WG under TC 309 on the "Governance of organizations"(SN, 2024). An example of how TCs can be structured is given in Figure 1.3 for TC 184. ISO places a strong emphasis on consensus when developing standards, but parts of the standardization process is also a question of majority votes. Two-thirds of ISO's member bodies must approve of a standard to send it forward, and no more than a quarter may actively oppose it (Murphy & Yates, 2009, p. 30).

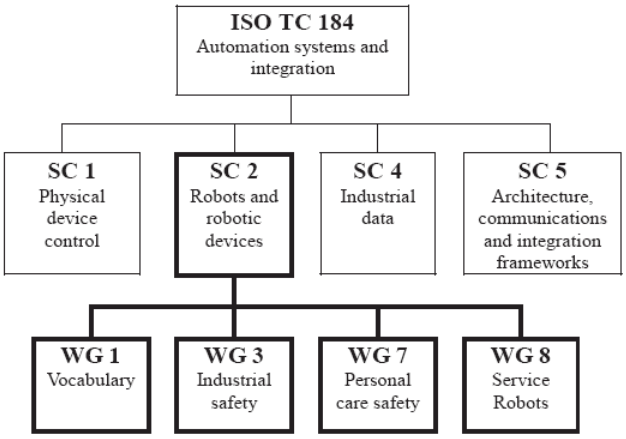

Figure 1.3: Organizational chart within technical committees (TCs), taken from Mitka (2016).

P-members are the main actors when it comes to standardization. National bodies that are P-members can propose changes and vote on developing standards, while national bodies that are observing members (O-members) are only allowed to follow the process. Representatives from national bodies that are O-members can attend meetings and receive documents, but their role is mainly informational, allowing them to stay updated on developments without directly influencing decision-making. Representatives from P-member bodies, on the other hand, have the right to vote on proposals, draft standards within the committee and are expected to contribute to the development and revision of ISO standards.

A distribution of P-members, O-members and Secretariat holders (which are technically also P-members) can be found in Figure 1.4. However, notably, behind these quantitative numbers lies substantial variation in activity levels (Alshadafan, 2020). Participation requires financial resources, for example to travel to meetings. Language barriers, administrative capacity and technical proficiency are other possible factors influencing ability to actively participate in standardization work. As one of

ISO's early Secretary-Generals, Olle Sturén, said: "Anyone who thinks that attendance at technical committee meetings is a comfortable, touristic experience is mistaken. Standards making is a hard profession and makes tremendous demands on participants if the standard is to be good and welcome for world-wide application. When sitting on an ISO committee, you are often in the company of the best brains in the relevant industry, and somebody who is not completely confident technically may hesitate before contributing the mildest comment." (Murphy & Yates, 2009, p. 32).

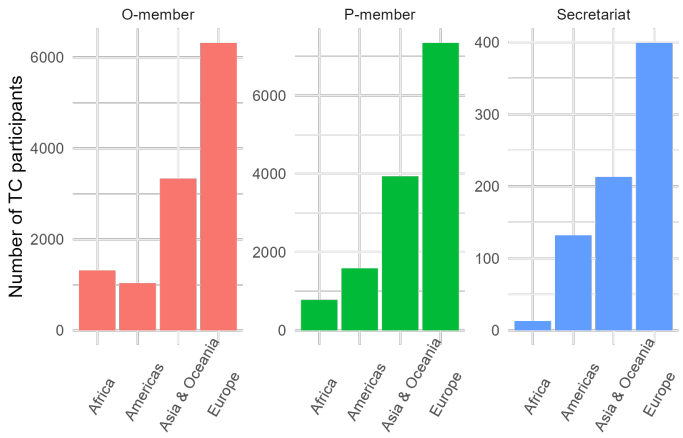

Figure 1.4: Number of Secretariat holders, P-members and O-members of ISO's technical committees in 2020 by continent.

Besides participating in TCs, countries may assume leadership roles such as secretariat, chair, or convener. The secretariat, responsible for leading TCs, is initially held by the member body proposing the TC, and thereafter any member body that volunteers for a specific period. Holding the secretariat can be a significant source of power in the standard-setting process, as it involves managing information flow, access, and agenda-setting (Hallström, 2002, p. 100). However, it is also a very time-consuming and labor-intensive role, and the decision to hold a secretariat is therefore often be a question of what key industries in that country may win or lose from doing so (Murphy & Yates, 2009, p. 31). Switzerland, for example, renowned for its dominance in the global watchmaking industry, has held the secretariat of TC 114 Horology since the committee's inception in 1964.

Recently, scholars have noted how China, along with its growing economic influence, is increasing its influence in international standardization processes (T. Rühlig, 2023a). For example, over the past two decades, there has been a significant increase in ISO secretariats held by China, as can be seen in Figure 1.5. This is a deliberate strategy encapsulated in projects such as "Made in China" and "Standards 2035", in which

China aims to become technologically self-sufficient and take a leading role in setting global standards, particularly within emerging technologies such as 5G, the internet of things and artificial intelligence (T. N. Rühlig & Ten Brink, 2021; Seaman, 2020).

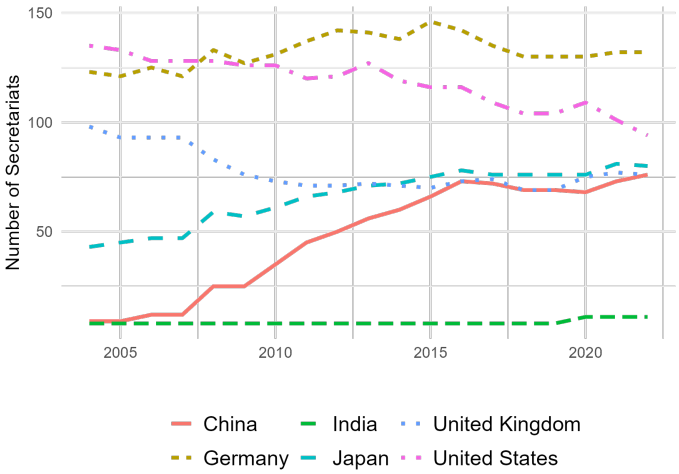

Figure 1.5: Number of Secretariats held by some core countries, 2004 - 2022.

China's growing prominence within international standardization proves a salient display of how international standardization can be contested. Conflict has for example surged between the US and China in cases such as the WAPI and TD-SCDMA standards. Here, China's security concerns drove its advocacy for alternative standards, but faced pressure from international trade partners like the US, who invoked commitments from trade agreements (Kim et al., 2020; Padula & Pizetta, 2022). In these two cases, China was unsuccessful in negotiating alternative international standards, leading to a different strategy in the standardization of the 5G initiative (Padula & Pizetta, 2022).

While this is a fairly recent example of contestation within standardization, these disputes are not new. In the midst of expanding economic globalization and technological booms, the strategic rivalry between China and the US resembles that of Germany and the United Kingdom in the nineteenth century, with standard-setting being among the central themes (Markus Brunnermeier & James, 2018). Yet, interest in the politics of standardization grew in political science first in the 1990s, as scholars of IR increasingly began to explore the involvement of private actors and processes in global governance (Peña, 2015).

1.3 Theories of the politics of standardization

Many scholars view standard setting bodies as representing a form of "transnational private authority" (Graz, 2019). Alongside formal organizations (such as nation-states) and markets, they are part of a "power triangle" that governs socio-economic affairs (Brunsson, 2002; W. Higgins & Hallström, 2007). However, at the same time, standards are highly technical objects, founded on scientific discovery and functional rationality. This is precisely what makes standardization a depoliticized endeavor. Technical rationality obscures the contested nature, the negotiations and requirements for legitimation, that come with standardization processes. Loconto and Busch (2010) argues that the political aspects of standards are often abstracted away, coining acts of standardizing "highly political attempts to remove politics from the exchange process [...]". To better understand how standardization can be viewed as either a technical or political process, this section explores various theoretical perspectives on the drivers and motivations at play in standardization and situates the dissertation within these perspectives.

Sociological institutionalism and political realism

Major theoretical approaches in international relations (IR) are applicable to the field of standardization. Mattli and Büthe (2003) suggest in two particularly relevant approaches; sociological institutionalism and political realism. When it comes to standardization, both of these perspectives acknowledge that standards solve the purpose of coordinating different "technical models, different engineering philosophies, different approaches to consumer protection, environmental regulation, and so on" (Mattli & Büthe, 2003, p. 9). However, they differ in their perspectives about the nature of coordination. While sociological institutionalism highlights the ability of standards to produce universal norms of scientific rationality which can shape actor behavior, political realism emphasizes how standardization negotiations can be shaped by states' power and self-interest.

The difference between these perspectives is usefully displayed through game theory. Both theoretical approaches acknowledge that standardization processes alleviate coordination problems that would otherwise not be solved optimally, such as in games of the Prisoner's Dilemma type (Büthe & Mattli, 2010a). To see this, consider a game with two firms holding incompatible standards. Both actors might view adopting a unified standard as beneficial, as it could expand market shares, enhance economies of scale and innovation potential, and reduce administrative expenses. However, they are also aware that aligning with the other firm's standard would result in significant transaction costs. Thus, both firms abstain from changing their standards, leading to an overall suboptimal outcome. This game is visualized in the top left corner of Table

1.1. Committee-based standardization may be particularly suited to alleviate these kinds of problem, as it allows stakeholders to meet with the sole purpose of negotiating standards under the leadership of an institution, introducing the coordinating aspect that is missing from Prisoner's Dilemma games (Calvert, 1992).

However, even when actors share a desire for a common standard and can communicate, coordination problems arise (Snidal, 1985). How will the actors agree on a common solution? These coordination problems may be "simple" or "complex", as demonstrated in Table 1.1. Simple games arise when the actors want to coordinate and are indifferent to the solution, for example whether to drive on the left or the right side of the road. In this situation, there is no conflict between individual and collective rationality, nor is there a collective action problem. This is shown in the bottom left corner of Table 1.1. Here, achieving an outcome that benefits both players and the collective simply requires communication and common sense. Another example of simple games include situations in which both parties view one standard option as superior. In these cases, actors must simply be able to deliberate to reach that solution, as shown in the bottom right corner of Table 1.1.

These coordination games reflect the sociological institutionalist perspective on standardization. Loya and Boli (1999) first applied this perspective to international standardization. They draw on the world society approach (Meyer et al., 1997) to argue that "global standardization is not reducible simply to the workings of the capitalist world or the interests of states" (Loya & Boli, 1999, p. 171). Instead, drawing on a constructivist notion of institutions, they hold that institutions at the international level provide actors with various roles and scripts, which again prescribe "logics of appropriateness" (Mattli & Büthe, 2003, p. 12).

In the sociological institutionalist perspective, standardization is a negotiation between technicians and engineers who share a consensus on universal technical and scientific knowledge, and therefore, they argue, standards are built on "world-cultural values of universalism, rationality and egalitarianism" (Loya & Boli, 1999, p. 192). These standards again prescribe norms for states' behavior. This view highlight the neutral and universal aspects of science, and fits with the description of early standardizes as "practical men" who "wanted science to be applied to improving human life" (Murphy & Yates, 2009, p. 14). Thus, Loya and Boli (1999) dismiss distributional conflict or power resources as drivers of standardization, arguing that the "deadly competitive struggle between states is not permitted to shape the products of global standards organizations" (Loya & Boli, 1999, p. 196). This perspective is well suited to understand simple coordination games, where participants face no trade-off of choosing one solution over others (Mattli & Büthe, 2003).

Prisoner's Dilemma

		Player 1	
		Coordinate	Defect
Player 2	Coordinate	3, 3	1, 4
	Defect	4, 1	2, 2

Complex coordination game (realist perspective)

		Player 1	
		Standard A	Standard B
Player 2	Standard A	4, 3	2, 2
	Standard B	1, 1	3, 4

Simple coordination games (sociological institutionalist perspective)

		Player 1	
		Standard A	Standard B
Player 2	Standard A	4, 4	1, 1
	Standard B	1, 1	4, 4

		Player 1	
		Standard A	Standard B
Player 2	Standard A	4, 4	2, 1
	Standard B	1, 2	3, 3

Table 1.1: Payoff matrices for different games in standardization negotiations.

Another situation arises in "complex" coordination games. Here, actors seek to coordinate, but they face distributional costs associated with the final solution, as illustrated in the top right corner of Table 1.1. Unlike simple coordination games, these situations offer numerous "Pareto-improving" options, where everyone is better off and no one is worse off than they were initially. The extent of benefits can, however, vary greatly among the actors, and therefore have several Nash equilibria (Krasner, 1991). In the game shown above, these are (4,3) and (3,4). Whoever gets their preferred solution depends on the power distributions of the game, for example which player who acts first. This scenario might occur when, for instance, two firms have developed distinct technical solutions. While they both favor adopting a common standard, selecting the other firm's solution could entail significant transaction costs. Such distributional differences can lead to conflicts over the chosen standard and since a chosen standard can produce path dependencies and cement long-term advantages, these types of games may give rise to "standardization battles" (Büthe & Mattli, 2010a).

These situations inform the realist perspective on standardization. In contrast to the sociological institutionalist perspective, the realist perspective acknowledges material interests and power as central drivers of standardization negotiations (Mattli & Büthe, 2003). Here, technical solutions are not seen as separate from politics. Rather, expertise is shaped by the battle for authority among technical approaches, influencing the allocation of costs and benefits. For example, in developing an international standard on quality management, the Canadians fought to include four levels for the scope of work on quality because this reflected their national standard. Final negotiations, however, concluded on three levels (Hallström, 2004, p. 64).

My argument is aligned with the political realist perspective and contrary to the sociological institutionalist perspective, that standardization processes frequently involve contested negotiations that are not always inherently regarded as legitimate based solely on their technical rationality. Actors can exert first-mover advantages and use standards to promote their agenda. T. Rühlig (2023b) proposes four dimensions on how actors can exert influence through standards; ideational, economic, legal and political. The ideational dimension points to the inherent values contained in and established through standards. This dimension highlights that standards embody values and may involve ethical considerations, such as guidelines for algorithmic bias and data privacy. On the economic dimension, a standard-setter gains economic advantages by licensing schemes that benefit the technology-owner, while potentially imposing costly restructuring for technology-adopters. On the legal dimension, both national and international laws encourage the adoption of standards, such as Article VI: 5b GATS in the WTO framework which stipulates that international standards should be embraced if it prevents trade from becoming unduly burdensome. On the political dimension, standards might create lock-in effects in which a country becomes reliant on another country's technology, an especially critical scenario if the technology includes

important infrastructure such as railways or cybersecurity.

In short this dissertation is mainly situated along the realist perspective, which doubts that international institutions can constrain power, but recognizes that the exercise of power can be facilitated and legitimated through international institutions, such as through actors shaping the standardization process (Mattli & Büthe, 2003). There are, however, other perspectives that also motivate the argument of the dissertation, both of which are presented below.

Institutional complementarities

While the realist perspective has met resonance with many scholars (e.g. D. Drezner (2001)), it has been criticized for being overly state-centric. After all, most standardization organizations, including ISO, are non-governmental institutions in which states are not themselves members. Instead, the members are national standard bodies which organize private interests on the national level[8]. Thus, Mattli and Büthe (2003) introduce the institutional complementarities approach. They argue that the degree to which countries are efficient in promoting their preferred standard in international fora, such as the ISO, depends on whether the domestic organization of private interests facilitates efficient negotiations internationally (Mattli & Büthe, 2003, pp. 17-18).

Mattli and Büthe (2003) identify two institutional variations that affect ability to negotiate standard internationally. The first is the level of consultation and coordination among domestic actors. They contrast market-based systems with consensus-based systems. Market-based systems incentivize competition and the protection of proprietary information. Consensus-based systems foster cooperation and consultation, seeking to aggregate preferences and establish a unified national standard rather than relying on competition.

The second institutional variation is the degree of organizational hierarchy among national standardization organizations. Less hierarchy poses a disadvantage in international standardization negotiations because it reduces coherence of divergent interests. On the contrary, more hierarchical organizations clearly designate one representative who can speak for the national standardization body. Thus, the institutional complementarities approach suggests that countries with consensus-based and hierarchical domestic standardization systems have an advantage in effectively voicing arguments and preferences in international negotiations, because they can more easily present with a single voice (Mattli & Büthe, 2003, p. 22).

[8]Although the work done by national member bodies is often a question of government delegation (D. W. Drezner, 2004), the institutional complementarities perspective argues that holding a too state-centric view still obscures the institutional dynamics of the private sector.

Mattli and Büthe (2003) use the EU and the US as an example. While EU standardization policy was motivated by economic integration, standardization in the US was motivated by competition for market acceptance. This led to a plurality of actors such as trade associations, professional societies and national standardization bodies developing potentially contradictory standards, with no strong national standardization body to enforce the pursuit of a single national standard. European countries, meanwhile, were "centralized, coordinated, regulated, subsidized, and inclusive" (Mattli & Büthe, 2003, p. 25). They feature one national standardization body that represents the national interests, and government regulations both require and subsidize the inclusion of a broad set of stakeholders into standardization work, including industry, consumer groups and public interests. In addition, Europe has a regional level of organized standardization, the European Committee for Standardization (CEN) and the European Committee for Electrotechnical Standardization (CENELEC), which further serves to enhance coordination and organization hierarchy. This makes European countries more efficient in international standardization processes, such as in the ISO.

There are, of course, other variations between countries. Krasner (1991) notes that the Japanese standardization system is much like the EU system in that it is driven by a central national SDO and has high coordination between government, public organizations and industry. However, it is more influenced by government than the EU. The Eastern Bloc was historically more centralized, but also more protectionist, favoring standards to keep control of domestic markets, promote socialist principles and maintain political and economic independence from the West. It is worth noting that Krasner (1991) focuses on the Cold War, and many Eastern European countries have come closer to the EU standardization system since then. However, research indicates that variations persists, including separation from international standardization and low levels of stakeholder participation, which are characteristics of the Russian standardization system (Gulakov et al., 2020). Given China's increased prominence in international standardization, its highly state-centric standardization system has also been contrasted with that of the EU and the US (T. N. Rühlig & Ten Brink, 2021; Yang et al., 2023).

The limited availability of data on national standardization bodies and their institutional variations restricts my ability to fully engage with the institutional complementarities perspective in this dissertation. However, with future data on the institutional composition of these bodies, this perspective could open up various research avenues. For instance, on could ask whether state-centric or market-based systems are more effective in advancing their preferred solutions for international standards in fast-moving ICT technologies.

Systems theory and political steering

Where Mattli and Büthe (2003) differentiate between national standardization institutions, Peña (2015) draws on Luhmann's system theory to offer a perspective on the politics of standardization that differentiates between various functional rationalities. This perspective rejects the realist and social institutionalist notion that standardization is a product of some dominant instrumental rationality, whether it emerges from negotiations or a rational and universal ideology. Rather, standardization is a form of political steering within functionally differentiated contexts. These contexts are defined by various function systems organized in separate entities such as the economy, politics, science, law, religion, mass-media and education (Peña, 2015, p. 57).

Because various functional systems self-organize their complexity with independent logics, coordinating between these systems is challenging. This is where the concept of steering becomes relevant. The political system is unique in its role of establishing collective coordination across various social systems, in which it uses logics such as power, hierarchies and rules. However, due to their functional autonomy, power cannot replace the operations and specific functions of other systems: "it cannot set a price, find the cure for cancer or define what is beautiful. [I]t can only produce certain irritations to orient systemic behavior, such as grant funding to certain research institutes or cap prices through law" (Peña, 2015, p. 60).

Standardization emerges as a way to coordinate across diverse functional contexts. To do so, they must be sensitive to the conditions of operation of these other systems, hence the consensus-based model of standardizing. Thus, different organizations can view various standardization procedures as legitimate or illegitimate depending on their functional system, and "a standard can be technically valid, economically convenient (for some) and politically illegitimate (for others)" (Peña, 2015, p. 465). Timmermans and Epstein (2010) have also made a call for employing a differentiated approach to standardization, in which standards emerge in different social, cultural, economic, and political contexts with equally varied outcomes for those affected by them.

While mainly operating from the realist perspective, one article in this dissertation engages with the systems theory approach. The second article argues that various types of standards require different types of legitimation, because they regulate different functional systems, and these functional systems have their own yardsticks on how to evaluate legitimacy.

1.4 Research design

This section outlines key foundational choices in the dissertation, focusing on the philosophy of science and methodology. The first part offers a mapping of various philosophical approaches to the study of standards, positioning this dissertation within

that framework. The second part details how the new database introduced in the first paper facilitates the application of quantitative methods to better explore causal relationships, while also addressing potential limitations of this approach and the remedies implemented to address them.

Philosophy of Science and the Politics of Standardization

Standards are "formula that describe the best way of doing something" according to ISO's own webpages. This is a bold statement, ontologically speaking. It assumes that there exists something akin to an overall "best solution" in the world, and, epistemologically, that this solution can be found through expert negotiations. Yet, although being bold, it is not a rare view. Many standard development organizations (SDOs) are composed mostly of engineers who have learned to make a sharp distinction between politics and science and often see standards as "purely technical" (Cech & Sherick, 2015). Also among standardization scholars, this functionalist view of standards has seen its use, as described in section 1.3 on the sociological institutionalist perspective and its belief in technological supremacy over political and capital interests (Loya & Boli, 1999).

Questions of ontology and epistemology become central to the study of politics of standards, because the development of standards themselves rely on presumptions made about the world and how we can acquire knowledge about it (Feng, 2003). This section reflects on various ontological and epistemological positions within the study of the politics of standards, and situates this dissertation within that spectrum. The discussion is summarized in figure 1.6, where I place the various perspectives discussed in section 1.3 into a model of various ontologies and epistemologies in political science adapted from Furlong and Marsh (2018). Differing from Furlong and Marsh (2018) and aligning with Hay (201), I swap the term "anti-foundationalism" for the term "constructivism" to match the vocabulary of other works that touch upon the ontology and epistemology of the study of standards. Furthermore, I echo the caveat of Furlong and Marsh (2018) that the model is a simplification meant to provide an overview, and that there are fleeting stances within each of these perspectives.

The foundationalist approach assumes that there exists a world, a reality, independent of our knowledge of it. The constructivist approach understands reality to be generated by the actors who define it, and who are also guided by social, political and cultural processes in their environment. Closely tied to different ontologies are their epistemologies. The beliefs we have about the world shape beliefs about how we can acquire knowledge about it. From a foundationalist stance follows an epistemological belief that reality is something we can uncover through diligent observation. One can establish relations between objects by studying them, find theories that explain their interdependence and predict future developments. It is a stance that aligns with

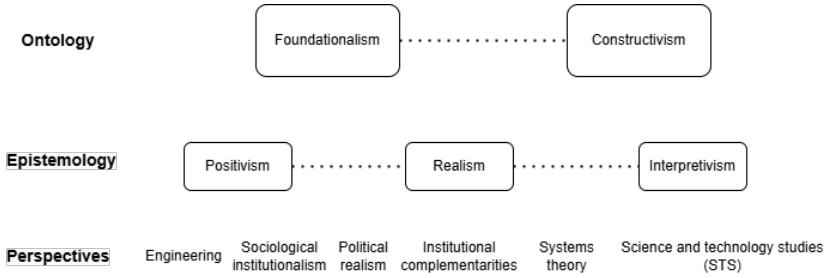

Figure 1.6: Ontologies and epistemologies of various perspectives on the study of standards and standardization.

deductive hypothesis testing of Karl Popper. Furlong and Marsh (2018) distinguishes between positivism and realism, with the latter acknowledging that some social structures are influential but not directly observable. Meanwhile, if one assumes there to be more than one single reality, then gaining knowledge about it requires understanding rather than explaining. In an constructivist ontology, reality, and the different versions of it, is something to discover rather than uncover. Epistemological stances reject the idea that one can build theories and test them, and they tend to focus on understanding the meanings of social practices, favoring inductive approaches, for which Furlong and Marsh (2018) identify an interpretivist epistemology. As such, the assumption that a "best solution" exists and that it can be uncovered by experts operating under norms of scientific rigor and objectivism, is arguably a foundationlist stance with a positivist epistemology.

With regards to standards, most political scientists deviate from the positivist stance and acknowledge the vital role of contextual factors, actor perspectives and political forces in standardization. Feng (2003) suggests that politics' impact on standardization can be understood by either studying the interests of actors or the institutional constraints they operate within. Focusing on actors' interest would quickly translate into a political realist approach described in section 1.3, for which the "interests of people at the negotiating table dictates what standard will be chosen" (Feng, 2003, p. 105). Meanwhile, the institutional complementarities approach also described in section 1.3 overlaps with the institutional focus, in the idea that "institutional roles have a significant influence on the outcomes of standardization debates" (Feng, 2003, p. 105). Although Feng (2003) refers to these approaches as constructivist, I would rather classify them as realist in the context of this discussion. These views assume that standardization processes are driven by complex dynamics which can partly be observed, but that they cannot be understood as a direct translation from expert deliberation to finding the technically optimal solution. Instead, they acknowledge the existence of broader structures, actors' interests and institutional constraints, which

shape the standardization process in addition to the participants' technical competence. Last, regarding the perspective of Peña (2015) on standardization as political steering, Luhmann's system theory is often argued to lie somewhere in between realism and interpretivism due to incorporating elements from both, for example by identifying various knowledge systems that produce different realities, but never the less guide behavior within that knowledge system (Matuszek, 2015).

To situate this dissertation, its ontological position is foundationalist and its epistemological position is largely that of a realist view. Attempting to *observe* the politics of standardization is to acknowledge that these political dynamics exist and can be observed through a more or less objective lens. Even the second paper, which focuses on the legitimation of various standards and draws inspiration from the systems theory account given by Peña (2015), finds its roots in foundationalism and realism. While this is a useful approach for this dissertation because to argue that something is generally political is to argue that political processes exist and can be observed, other approaches may conceptualize politics as something more relative and individual. To contrast the orientation of this dissertation, there is a large body of research that studies standardization in a constructivist light, particularly within science and technology studies (STS).

STS is an interdisciplinary field that deals with the creation, development, and consequences of science and technology in context of its history, culture or social constraints. STS scholars emphasize how technology in general, and standards in particular, construct reality by creating order. This order is generated whenever scientists and engineers agree on an observation, interpretation, phrasing or theory (Sismondo, 2011, p. 147). However, this order is not given; it is not uncovered by experts. Rather, scientists and engineers construct but one type of order (and reality) through these agreements, because the thought styles of scientists and engineers are also embedded in a context, influenced by their peers and predecessors through for example scientific paradigms (Kuhn, 1962). Therefore, STS approaches tend to be constructivist and interpretivist, assuming that "technical experts, like everyone else, cannot see all sides of a problem, but instead adopt certain perspectives that necessarily color their interpretation of what 'the problem' is" (Feng, 2003, p. 106). Beyond the production of standards, STS scholars may be concerned with how standards, once developed, are put into practice in different contexts. They are never simply diffused as they are, but rather *translated* into different contexts depending on actors, materials and technological realities present in that context. Thus, in this line of research, "[s]tandardization, if it occurs at all, is something to be explained rather than assuming that it is a logical outcome of the power of particular social groups such as standard-makers" (V. Higgins & Larner, 2010, p. 6).

Methodology and causality

I have situated this dissertation into a foundationalist ontology and a realist epistemology. In other words, the articles in this dissertation treats reality as something that exists independent of our knowledge of it and assumes that it can be uncovered through empirical study. This is the motivation behind collecting the StanDat database in the first place. Through empirical data, relations between variables can be estimated, and these relations can be used to produce models that help us generate theories, that again can offer predictions about the world. However, at the heart of this mission is the hunt for *causal relationships*, a hunt filled with obstacles (Risjord, 2023). In this section, I reflect on how well this data (and the methodology associated with them) enables me to make causal statements. Table I.1 gives an overview of the StanDat database – the main data source for this dissertation.

Notably, all the datasets in this database are panel data. Indeed, one of the big contributions of the StanDat database is to collect data on countries' participation in technical committees (TCs) over time using the Wayback Machine. Arora et al. (2016) outlined the promise of this method in the social sciences to improve access to historical data, and it has since been used to generate data for specific research questions, for example Bogers et al. (2022) and Blind and von Laer (2022). StanDat differs from these uses in that it collects and organizes historical data for not a single research question, but a general-purpose database.

Panel data contains information on several units over time, meaning that it combines cross-sectional with time-series data. It is useful because it enables two-way fixed effects estimators, which control for unobserved time-invariant factors within units (such as social norms within a TC) and for time-varying factors that affect all units similarly (such as global shocks). By controlling for these unobserved variables that may be confounding, observational studies are brought one step closer to identifying causal effects (Cunningham, 2021).

The reason why panel data improves on the ability to isolate causal relationship has to do with the nature of causality. I follow the *potential outcomes framework*, which posits that causal effects can be conceived of as $Y_i(1) - Y_i(0)$, where $Y_i(1)$ denotes the potential outcome under treatment, and $Y_i(0)$ the potential outcome with no treatment. The effect of the treatment on a given unit is therefore the difference between being exposed the given treatment or not. For example, will a dyad increase its trade when they sit in the same technical committee (TC)? To find a causal effect, we need to observe that dyad both sharing and not sharing TC seats at the same point in time, which is clearly impossible. Therefore, the individual causal effects are fundamentally unobservable.

Category	Datasets	Time series	Description	Source and method
Standards	Status, SDGs, Lifecycle	1951 - 2023	Data on specific standards, e.g host TC, life cycle, current status, edition, pages, sustainability goals and ICS code.	www.iso.org with sublinks to every standard. Collected using webscraping.
TC-membership	Countries, Organizations	2002/4 - 2023	Data on membership in technical committees and subcommittees, for national member bodies and organizations.	Wayback Machine. Collected using the Wayback Machine API to scrape data.
Historical	Membership, Technical committees	1947 - 2015	Membership in ISO over time, including type of membership and function of membership, and year of establishment for various TCs.	www.iso.org. Parsed from pdf in public archive (see Appendix). TC establishment scraped from webpage.
Certifications	Per country, Per industry, Per country and industry	1993 - 2020 (but varies depending on ISO series)	Certification of ISO standards. The annual ISO survey documents the number of certifications reported by certification bodies accredited by the International Accreditation Forum per country, industry and ISO series.	The ISO Survey. Parsed from excel files.

Table 1.2: Overview of the StanDat database.

One way around this is through experimental methods. $Y_{j1}(1) - Y_{j2}(0)$ will correspond to $Y_i(1) - Y_i(0)$ if there are no selection mechanisms. If a dyad's tendency to share TC seats and their tendency to trade were completely independent, this condition would be met. However, observational studies tend to violate this requirement. A dyad may, for example, both share TC seats and be engaged in trade because the two countries have a long history of cooperating.

Therefore, observational studies often depend on what is known as the *conditional independence assumption*, $Y_j(0), Y_j(1) \perp T \mid (X_j, Z_j)$. This assumption posits that the differences in outcomes *between groups* are independent of their likelihood of receiving treatment, given a specific set of variables. This condition is fulfilled when the researcher controls for all unknown causes of X and Y (Morgan & Winship, 2014). Thus, being able to control for time-invariant factors within units and for time-varying factors that affect all units similarly through two-way fixed effect significantly improves upon the ability to find causal effects.

Yet, controlling for all confounding variables is a daunting, some would say impossible, task. Fixed effects estimators can account for some variation, but not all. For instance, time-varying heterogeneity among units, such as fluctuations in leadership within TCs, is not controlled for by a fixed effects model. The analyses in this dissertation should therefore be regarded as approximations of causal relationships rather than exact estimates.

Another "causal criteria" that fixed effects models do not account for is that of reverse causality (Kellstedt & Whitten, 2018). This is a recurring challenge. In the first paper, robustness tests indicate that the relationship between TC participation and trade may go both ways, and it is theoretically challenging to identify dependent and independent variables. The second paper delineates between input and output legitimation, but it is possible that for example a TC becomes diversified, attracting a large variety of actors, *because* it produces many societal standards. And while the third paper assesses relationships between variables in multi-model and fixed effects model frameworks, there are many possible factors that can influence standardization efficiency.

Last, threats to causal inference may arise from measurement errors (Kellstedt & Whitten, 2018). First, as described in the first paper, about 28 percent of the units in the dataset on TC participation have been imputed, potentially introducing inaccuracies that could bias the results when included as an independent variable into the model. This is particularly problematic when there is reason to believe that the measurement errors are systematic. Given the random source of the measurement error in this case, namely whether the automatic program of the Wayback Machine makes a snapshot of the given webpages, there is little reason to believe that the measurement error is systematic. Furthermore, validation methods show an accuracy of nearly 90 percent, suggesting that these concerns are relatively minor.

Second, in several instances, I have utilized large language models (LLMs), specifically ChatGPT, to assist in coding categorical variables, such as determining whether a standard is physical or societal in my second paper. ChatGPT serves as a cost-effective coding assistant that has proven to be as effective as research assistants and crowd-coders (Gilardi et al., 2023). Its training on a large set of textual data enables it to perform a wide range of tasks (Kocoń et al., 2023). While the model's reliance on its training data may introduce potential biases or errors without certainty estimates, these concerns are limited in this context. I have employed it for tasks that do not involve complex evaluations that require extensive reliance on its training data, but I have provided specific information and promoted it to rely on this when classifying units. Additionally, the tasks do not require highly precise answers, which also reduces the threat of measurement error. I furthermore provide validation for all instances where ChatGPT was used.

Third, the measurement of complex concepts such as "legitimation strategies" and "geopolitical differences" inevitably relies on approximate proxies that cannot fully capture all aspects of these definitions and therefore not attain perfect validity (Cartwright & Bradburn, 2011). To mitigate this, I generate multiple operationalizations and evaluate the interchangeability of these measures in studies employing such complex concepts.

Overall, while the StanDat database poses a significant improvement to existing data on standards and standardization, it relies on the same assumptions that all observational studies do, including absence of reverse causality, controlling for all confounding variables and validity of measurements. As all researchers employing observational studies, I account for these assumptions to the best of my ability.

1.5 Summary of articles

This section gives a brief overview of the three articles in this dissertation. As mentioned above, I argue that standardization is subject to negotiations and reliant on legitimation, and therefore, standardization processes are ultimately political. As such, the articles operate from a realist perspective; expertise and power are intertwined.

The first article presents the data collection process and the final database on ISO standardization – the StanDat database. The second article investigates how different legitimation strategies pertain to different standards that regulate, respectively, purely technical issues and more societal issues. The third article explores how political and economic characteristics influence the efficiency of standardization negotiations, and how these processes are subject to strategic concerns.

All articles argue for the political undertones of standardization, whether through negotiations, legitimacy, or, in the case of the first paper, by proposing various research questions for political scientists to explore in relation to standardization. However, the

articles also differ. The first article includes an analysis of the relationship between participation in standardization and trade, raising a question that is both political, but also deeply economic. The second paper examines ISO as a case study of transnational private institutions (TPIs), making the broader argument that researchers should move beyond studying only input and output legitimation of TPIs, to also include technocratic and democratic legitimation strategies. Meanwhile, the third paper uses ISO as a case to illustrate how states can enhance their technological sovereignty through technological output diffusion, specifically by maneuvering international coordination games.

Article 1: Presenting the StanDat Database on International Standards: Improving Data Accessibility on Marginal Topics

Compared to other science and technology indicators such as research and development (R&D) and patents, there is no single database providing standardized information on the workings and output of standardization organizations (Blind, 2019). This has led to a research field sporting a wealth of studies that focus on specific areas such as standard series (Balzarova & Castka, 2012), sectors (Shahin, 2024), or regions (Storz, 2007; Wattnem et al., 2022). While this enriches the field with depth, it also causes a fragmentation that has led some scholars to highlight the need for a unifying theoretical framework and "real data" to test empirical expectations (De Vries et al., 2018, p. 56). Data accessibility is, however, a challenge. Of the comparative studies that do exist, they tend to rely on self-administered surveys (Blind & Heß, 2023; Mattli & Büthe, 2003), commercial data providers (Blind, 2007; Gamber et al., 2008), or more narrow data collection of official information (Blind & von Laer, 2022). In short, finding data on standards is costly, either in terms of money or time.

To address this issue, this first article introduces the StanDat database. StanDat is a comprehensive database made from scraping the webpages belonging to the International Organization for Standardization (ISO). These days, a lot of digital information is readily available on the internet, but availability does not ensure accessibility, and the steps needed to gather and process data to tackle research questions present challenges for many social scientists (Lazer et al., 2009). Poor data accessibility can greatly influence which topics that are studied, potentially leading to an availability bias in the social sciences (Mahrt & Scharkow, 2013). Therefore, this paper has a two-fold focus; primarily to introduce the StanDat database and secondarily to demonstrate how digital data can be collected and made available for a larger research community.

The utility of the StanDat database is demonstrated through various applications. First, the database can be used to produce descriptive statistics more tailored to the research question at hand than relying on existing sources such as annual reports. Second, it can be used to assess scope conditions of previous research that has been

confined to more narrow areas such as specific standard series, sectors or regions. And third, by combining the StanDat database with other datasets, it opens up for new analyses. The article provides various examples of these applications, including an analysis overlapping standardization networks and trade networks. Here, I find that there is a significantly positive relationship between joint participation in ISO technical committees and bilateral trade. This suggests that harmonized expectations, knowledge sharing and signaling effects connected with joint standardization participation may boost trade, although reverse causation in which trade boosts joint standardization efforts at ISO might also be possible. The other two articles of this dissertation demonstrate further applications of the StanDat database.

Article 2: Legitimation Strategies in Transnational Private Governance: Evidence from the International Organization for Standardization

The second article uses the International Organization for Standardization (ISO) as a point of departure to study the legitimation strategies of transnational private institutions (TPIs). A legitimation strategy can be defined as a goal-oriented activity that aims to establish, build and maintain support among core stakeholders (Tallberg & Zürn, 2019). Legitimation therefore differs from the notion of "legitimacy", which has received more attention for TPIs (Beisheim & Dingwerth, 2008; Koppell, 2010; Macdonald & Macdonald, 2017; Risse et al., 2006). Legitimacy addresses an institution's support, either normatively or sociologically, and here, scholars have discussed how TPIs may find themselves in a squeeze between democratic and technocratic legitimacy. On one hand, TPIs often fulfill needs of expertise and efficiency, thus relying on technocratic legitimacy (Büthe & Mattli, 2011; Dingwerth, 2017), but on the other hand, TPIs make rules and regulations that potentially affect a global range of stakeholders, raising demands for democratic legitimacy, despite their institutional basis guaranteeing neither widespread participation nor judicial accountability (Black, 2008; Risse et al., 2006). Because ideals of broad participation and transparency can conflict with ideals of decision-making efficiency (Ruggie, 2007), this poses a paradox when applied to the question of TPIs' choice of legitimation strategies. When and why do TPIs pursue technocratic and democratic legitimation respectively?

Previous work on the legitimacy of TPIs tend to focus on input and output legitimacy (Botzem & Dobusch, 2012; Scharpf, 1999). This conceptual framework is not well versed to answer the question posed above because it conflates democratic legitimacy with input legitimacy and technocratic legitimacy with output legitimacy, even though it is possible for democratic legitimacy also appear in the output phases of a process, and vice versa for technocratic and input legitimacy (Dellmuth et al., 2019). Therefore, I apply a conceptual framework drawn from the literature on international

organizations, which organizes legitimation strategies into a two-by-two table (Tallberg & Zürn, 2019) and use this to study the legitimation strategies of ISO.

One potential driver of shifting legitimation strategies is the type of issue a TPI addresses, because different norms (which guide stakeholders' acceptability) apply to different issues (Bernstein, 2011). As described in section II.5, ISO has witnessed an expansion from producing physical standards to also increasingly producing societal standards (Ruwet, 2011). Utilizing this shift to study whether differing issue areas accompany different legitimation strategies, I find that technocratic legitimation is more prevalent for physical standards, while for the more recent societal standards, ISO pursues democratic legitimation. This pattern persist in both the input and output phase, underscoring the utility of using an expanded conceptual framework for TPIs' legitimation strategies. Thus, this article aligns with the system theory approach detailed by Peña (2015) and presented in section 1.3, arguing that various logics of legitimacy apply to various function systems, whether societal or physical.

In extension of this study's results, I call for more research into the legitimation strategies of TPIs. TPIs have been found to increasingly regulate societal issues like labor, human rights, and the environment (Bartley, 2007) and they have proliferated within the field of sustainable governance (Dingwerth, 2017). Furthermore, a notable body of research documents how TPIs use multi-stakeholder processes – a democratic legitimation strategy – to emphasize inclusivity and representation in their rule-making processes (Boström & Tamm Hallström, 2013; de Bakker et al., 2019; Moog et al., 2015; Schleifer, 2019). Thus, a fruitful question to ask is whether the patterns observed for ISO also extend to other TPIs.

Article 3: Geopolitics in International Standardization Negotiations: Outward Technology Diffusion and Technological Sovereignty

The third article explores how international standards can be utilized as geopolitical tools to obtain technological sovereignty. Technological sovereignty has become a hot topic over the past years, especially as the United States, Europe and China compete on access to core technologies such as semiconductors (Bown, 2020; Malkin, 2022). Technological sovereignty implies an absence of one-sided structural dependency on other foreign companies when developing key technologies that affects the state's political and economic sovereignty (Edler et al., 2023), and multiple scholars have argued that standardization can be used to enhance this (Blind, 2025; Freimuth, 2024; Malkin, 2022; T. Rühlig, 2023b). However, few studies have looked systematically into the geopolitics of standardization for a broader sample (Mattli and Büthe (2003) and Blind (2019) are some notable exceptions), and this is therefore the objective of the third article.

In the article, I argue that international standardization is a tool to pursue

technological sovereignty because it can function as a method to achieve "outward technology diffusion". While diffusion capacity generally refers to the ability to spread an innovation through a system or population (Ding, 2024a), the term outward technology diffusion here captures the ability to spread a preferred technology globally, to other states. The concept encapsulates the potential of standards to "have a broad impact and alter the course of future technological development" (Heires, 2008, p. 360).

Drawing from the literature on technology diffusion, I pose two expectations and test them using the StanDat database. The first expectation concerns the rate of strategic standardization in ISO. Strategic standardization entails producing international standards that correspond to domestic technology. Taking inspiration from the literature on standard essential patents (SEPs), I operationalize this as the similarity between domestic patents and international standards, measured through the similarity in abstract (Brachtendorf et al., 2023). Keeping with the literature on technology diffusion, one would expect strategic standardization to be more prevalent when the technology being standardized is a general-purpose technology (GPT), such as steam engines, telecommunication and energy infrastructure, as GPTs have been found to have more impact when diffused (Ding, 2024b). The second analysis therefore assesses the correspondence between strategic standardization and GPTs, finding that when the technology in question is GPT, the similarity between domestic patents and international standards is indeed higher, indicating that countries engage more in strategic standardization for GPTs than non-GPTs.

Second, countries with high bilateral differences along economic and political dimensions are likely to have different preferences with regard to technology diffusion, thus stalling and delaying the standardization negotiations, which again leads to lower productivity in producing standards (Acemoglu & Robinson, 2000; Assiotis et al., 2015; Comin & Hobijn, 2010). The opposite is expected to be true for countries with high political and economic closeness. I proxy several measures of bilateral political and economic closeness or distance, and aggregate these dynamics up to committee level. Thus, the analysis shows the degree to which committee work in ISO is affected by political and economic distance or closeness among participating states. The findings indicate that factors such as high bilateral tariffs and mutual participation in the same defensive alliances result in respectively slower and faster standardization processes, supporting the second expectation.

Overall, the article finds that international standardization processes at ISO are not immune to geopolitical considerations. Despite being a highly technical endeavor, the analysis indicates that (1) states engage in strategic standardization when anticipating large consequences from the outward technology diffusion that can follow from international standardization, and (2) differences along political and economic dimensions impact the process. The article contributes to the literature by assessing the degree to which standardization functions as a method to improve

technological sovereignty for a broader sample, and suggests a mechanism through which this can occur, namely outward technology diffusion.

1.6 Legality and ethics of web scraping

Web scraping is the primary method for data collection in this dissertation, a practice that has existed within a legal gray area for many years. Although the data gathered through this technique is typically publicly accessible, it is often not intended for large-scale aggregation and structuring. In this section, I will examine the broader legal implications of web scraping, concluding that these concerns are particularly critical for those who wish to use the data for commercial purposes or when it involves personal information, and therefore not directly relevant to my work. I then address ethical considerations related to scraping data from ISO's webpages, with a focus on algorithmic thinking (Luscombe et al., 2022).

Web scraping can be defined as the "automated extraction of information online" (Luscombe et al., 2022). Here, due to ISO's webpages being static, this is boils down the practice of detecting and extracting information from the HTML-pages. The legality and ethics of scraping have become particularly relevant over the past years, as tech companies building generative models utilize enormous scrapers to gather training data for their models. A recent example is the class action lawsuit *Paul Tremblay et al. v. OpenAI Inc, et al.*, where creative producers claimed that OpenAI unlawfully used their copyrighted work as training data[9]. To situate this project in that larger debate, this section discusses the legality and ethics of web scraping for this project.

Starting with the question of law, despite increased attention to the legality of web scraping, it can still be characterized as a "gray area" (Luscombe et al., 2022). No current legislation explicitly prohibits web scraping, but there are other legal frameworks that can limit and penalize scraping activity (Fontana, 2024). These legal frameworks include for example copyright, contract law, illegal access, competition, trade secrets and data privacy (Krotov & Johnson, 2023). Because I neither collect personal data nor intend to use it for commercial purposes, I will focus this discussion on legalization around copyright, contract law and illegal access.

There have been a host of cases related to these types of questions. While the general consensus seems to be that public data is open to use, there is less agreement on whether violating user agreements constitute a breach (Krotov & Johnson, 2023). In the US, this is well illustrated in the 2017-2022 case *LinkedIn v. hiQ Labs*. In this

[9]A California federal judge rejected most of the claims to copyright, following OpenAI's arguments that the output of the model is not similar enough to breach copyright laws, and that innovative transformations of fictitious work is allowed.

case, the Ninth Circuit court applied the *Van Buren* case[10] to rule that hiQ Labs had the right to scrape LinkedIn's webpages despite attempts to block them because they were not exceeding authorized access (Fontana, 2024).

The situation differs in the EU, as illustrated in the 2015 case *Ryanair v. PR Aviation BV*. Here, Ryanair sued PR Aviation BV for scraping content off its webpage to use for an application that compared flight prices. The European Court of Justice ruled that the scraping was not illegal because the data did not possess the creativity or originality required for copyright protection. Neither could Ryanair claim exclusive rights under the EU Database Directive, as the database had not involved a significant investment. However, the court ruled that a terms of a conditions prohibiting web scraping would be sufficient to render it illegal (Fontana, 2024). In other words, while public data is generally regarded as open to scrape, Terms of Service (ToS) enforcements may prohibit web scraping in the EU but not in the US. In this context, I note that ISO has a login mechanism for its members where they can access documents and personal information on TC members, of which obtaining access and scraping would potentially violate both ToS and GDPR regulations. However, the StanDat database relies purely on public data that does not require login credentials[11].

These cases are instances of disputes among commercial actors. However, collecting data for commercial purposes is one thing, using web scraping to promote scientific knowledge is another (Fontana, 2024; Krotov & Johnson, 2023). Luscombe et al. (2022) report of no lawsuits to their knowledge in major western democratic countries that stem from a researcher scraping publicly available data for academic use. However, even when operating in the legal gray areas, they encourage so-called "algorithmic thinking" – that is, considering the public interest before limiting oneself to "only scrape publicly available, unencrypted data sources to avoid legal risk" (Landers et al., 2016). Otherwise, they argue, too much information may be left for governments and corporations.

Algorithmic thinking involves ethically making use of digital data to answer research questions in the pursuit of the public good (Luscombe et al., 2022). These ethical concerns are not straightforward, but depend on various factors such as "on the data, on the research question, and on one's own politics and agenda" (Luscombe et al., 2022, p. 1039). Based on the ethical guidelines provided in NESH (2023) and UiO (2023), I find that there are in particular two groups one should be mindful of when

[10] In the *Van Buren v. United States* case, a police officer was charged for running license-plate searches through a law enforcement database in exchange for money. The Supreme Court assessed whether Van Buren was "exceeding authorized access" and thus violating the US Computer Fraud and Abuse Act (CFAA). It concluded that he *did not* violate this act because he used his password to access the information.

[11] It is also worth noting that legislation around scraping varies for each member state. ISO's headquarters are located in Switzerland, but during my inquiry on data availability with ISO, they emphasized that data on specific national members belong to them, leaving open the question jurisdiction.

considering the ethics of web scraping: (1) the units that data is gathered on and (2) the website owner. With regard to the first, there are differences between collecting personal data and non-personal data, and sensitive data and non-sensitive data. For example, if scholars were to scrape health data on individuals, ethical questions (and legality under GDPR) would immediately become prominent. Relying on algorithmic thinking, these scholars would bear a strong responsibility to weigh the potential risk of collecting and storing this information against the benefits to the public of doing said research (Gregory, 2018). Fortunately, my data is neither on persons nor is it of a sensitive character. Units are either standards, countries or organizations, and the variables are all public information of a non-sensitive character.

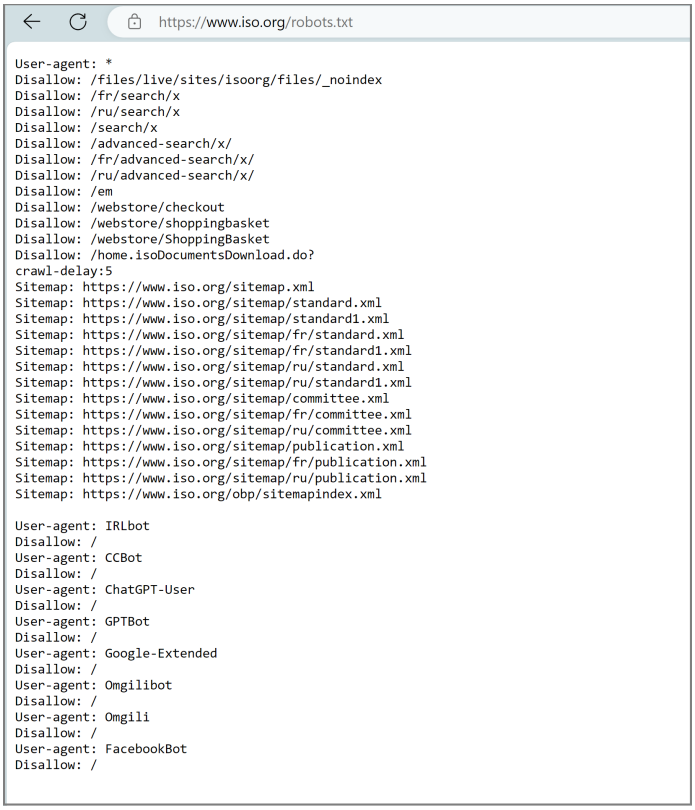

Figure 1.7: Robots.txt file for www.iso.org. Photo taken 06.01.2025.

Second, it is important to be mindful of the website owner when scraping. One should avoid overwhelming the server with too many and too frequent requests, as this could lead to crashes and pose unnecessary costs. Moreover, subject to algorithmic thinking, it is important to respect limitations set by the platform provider themselves by acknowledging access limitations and adhering to their *robots.txt* file. This file

describes behaviors that crawlers and scrapers should adopt when navigating the website. An image of ISO's *robots.txt* is given in figure 1.7. This file tells us that scraping is allowed for most sites except in the given subfolders, that scrapers should pause for five seconds before navigating to a new site, and that big crawlers such as IRLbot are not allowed to scrape anything. Thus, I integrate a five second pause between scraping in my code (which also prevents overburdening the server) and I avoid the given subfolders.

In short, I have discussed how the legality of web scraping is still a "gray area", although in the EU, websites' user agreements limit legal access to scraping public information. In my project, I have relied purely on public information not subject to user agreement limitations. For ethical considerations, one should consider the harm of scraping against the public benefit of collecting this information. This project poses no harm to the units, and I employ a mindful scraping procedure to minimize potential harm to the website owner.

1.7 Implications and future studies

In the field of global governance research, standardization has traditionally received limited scholarly attention. This is possibly due to its largely depoliticized nature, which results in it often being excluded from key discussions in political science. However, standards are important regulatory instruments and a core component of the concept transnational private authority, and witnessed by an increased amount of research into standardization over the last three decades. From regulating the dimensions of shipping containers to setting global guidelines on what social responsibility entails, international standards shape international relations and global dynamics.

This dissertation provides insights into the politics of standardization by analyzing dimensions of the political, specifically legitimation and negotiation, with a focus on the International Organization for Standardization (ISO). Having published a novel database on ISO standards, more research into the global governance of ISO standards using the StanDat database is highly encouraged. Examples of interesting avenues for research include how international standards facilitate global value chains, if international standards promote sustainable practices, and if standardization processes change as more developing countries enter the committees. Furthermore, because the study of standards is highly multi-disciplinary, StanDat can also be used by scholars in different branches of political science, such as organizational theory, and different disciplines, such as sociology, law and economics.

The StanDat database could also be expanded with more standardization organizations beyond the ISO. Some alternatives include the International Electrotechnical Commission (IEC), the European CEN-CENELEC, and the Institute of Electrical and Electronics Engineers (IEEE). There are, furthermore, multiple national stan-

dardization organizations that publish their own national standards and cooperate internationally. Open and transparent data on these standards, in the same vein as we have with patent data, would open up for many avenues of research that, for example, compare national standards to international standards. The web scraping approach used to generate the StanDat database could, given time and resources, be a method to begin collecting data for such a large database.

Overall, this dissertation argues that standardization is far from an apolitical endeavor, but is strongly embedded in the political landscape. Under the guise of producing innocuous regulations on nuts and bolts, international standards pose a form of transnational private authority, with all the power dynamics, legitimacy claims and distributional consequences that follow from that.

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Papers

Paper I

Presenting the StanDat Database on International Standards: Improving Data Accessibility on Marginal Topics

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Abstract

This article presents an original database on international standards, constructed using modern data gathering methods. StanDat facilitates studies into the role of standards in the global political economy by (1) being a source for descriptive statistics, (2) enabling researchers to assess scope conditions of previous findings, and (3) providing data for new analyses, for example the exploration of the relationship between standardization and trade, as demonstrated in this article. The creation of StanDat aims to stimulate further research into the domain of standards. Moreover, by exemplifying data collection and dissemination techniques applicable to investigating less-explored subjects in the social sciences, it serves as a model for gathering, systematizing and sharing data in areas where information is plentiful yet not readily accessible for research.

I.1 Introduction

It is no coincidence that, all across the globe, credit cards are 85.6 mm long and 53.98 mm wide, webpages start with HTTP, and all certified scuba diving guides have at least 60 logged dives in open water. These seemingly unrelated occurrences find their roots in international standards – a set of guiding principles that foster global interaction, harmonization of expectations, and a world-wide sense of familiarity and predictability.

Standards are an essential aspect of the globalization process, both emerging from and enabling it. For instance, shipping containers revolutionized global trade by enabling efficient shipping, but, importantly, their adoption rate across ports depended on harmonization through standards (Levinson, 2016). Indeed, the proliferation of standards has led scholars across a broad range of disciplines to study these regulatory initiatives, including their design, diversity, effectiveness and legitimacy as transnational regulatory tools (De Vries et al., 2018; Marx et al., 2012). This article aims to boost the growing body of research on international standards by introducing *StanDat*, a comprehensive database derived from the International Organization for Standardization (ISO). This database enhances access to descriptive statistics for qualitative purposes and facilitates the study of quantitative relationships, such as those between standardization and trade, innovation and economic growth (Blind et al., 2023; Swann, 2010). It can also be used to address questions related to the legitimacy of standards as regulatory instruments (Bernstein & Cashore, 2007) and how standardization can serve as a source of power (Rühlig, 2023)[1].

Previously, access to structured data on the topic of standards has been relatively scarce, despite plenty of information being readily available on the internet. Availability of digital data does not prescribe accessibility, and the harvest- and processing requirements needed to use these data to answer research questions pose barriers to many social scientists (Lazer et al., 2009). In a time where data collection techniques has allowed for a burgeoning body of datasets within international relations[2], it is worth considering how distinct topics such as standards may become understudied compared to topics with readily available datasets, potentially leading to an availability bias in the social sciences (Mahrt & Scharkow, 2013). Thus, in addition to introducing the *StanDat database*, this paper shows how a full-fledged database on the domain-specific topic of standards can be constructed through web scraping and made readily available to researchers, hopefully contributing to the expansion of research in this important field (De Vries et al., 2018).

[1] See Table I.2 for elaboration.

[2] For instance Zürn et al. (2021) (Authority of International Organizations), Schmidtke et al. (2023) (Legitimacy of International Organizations) and Sommerer and Tallberg (2016) (Transnational Access to International Organizations).

I.2 The politics of standards

Research on standards and standardization is incredibly diverse. First, studies span several disciplines, including management studies (Narayanan & Chen, 2012; Wiegmann et al., 2017), organisational studies (Botzem & Dobusch, 2012; Brunsson, 2002), law (Pauwelyn et al., 2012), economics (Swann, 2010; Weitzel et al., 2006; Yang, 2023), sociology (Timmermans & Epstein, 2010), political science (Abbott & Snidal, 2001; Büthe & Mattli, 2011a; Graz, 2019; Mattli & Büthe, 2003), and more recently, multidisciplinary approaches (Eliantonio & Cauffman, 2020; Olsen, 2020). Second, standards are produced and adopted at various levels, from the local to the international. Third, a wide range of topics are standardized, including for example education (Elken, 2017), human capital (Yarrow, 2022), child welfare (Sletten & Ellingsen, 2020) and the environment (Prakash & Potoski, 2006).

While it is beyond the scope of this paper to give a full overview of the standardization literature, the complexity illustrated above may explain why, despite an increasing volume of research, some scholars deem standardization to be an "under-investigated area of research" (De Vries et al., 2018, p. 57). Although the field has grown in popularity over the last decades (Yang, 2023), in a bibliometric study, Heikkilä et al. (2021) found that within economic textbooks, the words "standards" and "standardization" are seldom found in the word indices, and the relationship between standardization and economic growth has never been analyzed in the top five economic journals between 1996 and 2018. Arguably, the rich albeit fragmented literature has concealed the importance of this broad phenomenon to many researchers (Narayanan & Chen, 2012).

Yet, the political significance of standards has become increasingly evident to social scientists (Mattli, 2001). A standard can be defined as a "rule for common and voluntary use" (Brunsson et al., 2012, p. 616) "that structur[es] interaction" (Botzem & Dobusch, 2012, p. 739) and represents the "values against which people, practices and things are measured" (Loconto & Busch, 2010, p. 526). However, despite originating from expert deliberations, these values can be quite disputed. For instance, the effort to develop standards for humane animal traps was significantly delayed due to activism from animal protection groups, who advocated for a general ban of all animal trapping devices (K. T. Hallström, 2004). Another example of conflicting values and trade-offs concerns the creation of a global standard for wireless equipment. A few years after the Institute of Electrical and Electronics Engineers (IEEE) proposed the well-known Wi-Fi, China proposed the WLAN Authentication and Privacy Infrastructure (WAPI). Although WAPI promised better performance, it offered poorer privacy protections, and standard-setters settled on the Wi-Fi (Rühlig, 2023).

The widespread adoption of the Wi-Fi standard also exemplifies the enduring nature of certain standards; they can produce path-dependencies. The QWERTY keyboard

is a classic example within economics of how markets may lock in inferior outcomes. David (1985) argued that the QWERTY layout was designed to slow down typing on typewriters to prevent jamming, and suggested that a different layout would have been more efficient for computers. This demonstrates how standards (both de facto and de jure) can become so deeply entrenched that even suboptimal outcomes are difficult to change, benefiting some actors over others. Indeed, standards are powerful instruments for technology diffusion, and winning a "standardization battle" can have long lasting consequences. Ding (2024) has argued that diffusion, in addition to innovative capacity, is a core component of nations' scientific and technological power.

Within international relations, the topic of standards entered the research agenda in the 1990s, with the increased study of private actors in global governance (Peña, 2015). Standards are often viewed as governance tools (Abbott & Snidal, 2001), and today many scholars view standard setting bodies as a part of a "power triangle" that govern socio-economic affairs (Higgins & Hallström, 2007), posing a form of "transnational private authority" (Graz, 2019). StanDat facilitates further studies into the significance of standards in the global economy, to explore the reasons and circumstances under which they have an impact.

I.3 Data source: The International Organization for Standardization (ISO)

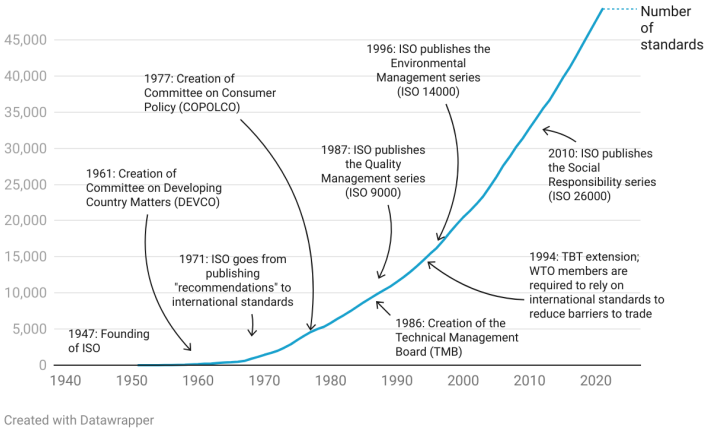


Figure I.1: Growth of ISO standards over time annotated with selected notable events in ISO's history.

StanDat is built from digital data harvested from the International Organization for Standardization (ISO), one of the oldest and most active standardization

organizations on the international arena (Heires, 2008). Other notable international standard-setting organizations include the European Committee for Standardization (CEN), the International Accounting Standards Board (IASB), the International Telecommunication Union (ITU) and the International Electrotechnical Commission (IEC) (Büthe & Mattli, 2010)[3]. While StanDat focuses on ISO standards, the approach demonstrated in this article can be used to also gather data on other organizations.

The ISO standards mapped in StanDat are global, generalist (i.e. regulate a range of topics) and widely distributed. Fifteen years ago, they were estimated to encompass approximately 85 percent of all international product standards in collaboration with IEC (Büthe & Mattli, 2011a, p. 29). At the time of writing, ISO sports a portfolio of over 25,000 standards organized within 834 technical committees and subcommittees [4].

Figure I.1 gives an overview of some historical highlights along with ISO's cumulative growth of standards. In 1971, ISO transitioned from making so-called "recommendations" to provide what they termed "international standards" (Murphy & Yates, 2009). The 1979 Tokyo Round resulted in the Technical Barriers to Trade (TBT) Agreement, calling for nondiscriminatory, minimally trade-restrictive standards aligned with international norms (M. Kim, 2018, p. 774). The TBT Agreement became part of GATT-WTO obligations in 1994, requiring members to harmonize technical specifications to reduce trade barriers (Jackson, 1997, p. 223).

Additionally, ISO has broadened its scope, expanding from purely technical fields into new societal fields. A standard series on Quality Management and Quality Assurance (ISO 9001) was published in 1987, and since then, ISO has expanded its portfolio into Environmental Management (ISO 14001) and Social Responsibility (ISO 26000) (K. Hallström, 2008; K. T. Hallström & Higgins, 2010). Hence, ISO has expanded its reach over time, impacting a wider array of stakeholders and expanding the issue scope covered by standards. To address issues such as representation and stakeholder concerns, ISO has established DEVCO, COPOLCO and TMB (Bijlmakers, 2023).

ISO has a decentralized structure based on a network of technical committees (TCs). Member countries are represented in these TCs by their most representative national standardization body. Per date, ISO hosts 171 national member bodies, with varying degrees of engagement, activity and influence depending on membership status, degree of participation, and number of experts[5]. Besides being members in TCs, national

[3]In addition, many standards exist solely at the national level, and some are created de-facto in the market (Suarez, 2004; Wiegmann et al., 2017). For an overview of different modes of standardization, see for example Kerwer (2005). ISO represents a *non-market based organization* producing *private* standards (Büthe & Mattli, 2011b).

[4]This is a very short introduction to ISO. For further details, see for example Heires (2008), Bijlmakers (2023) and Murphy and Yates (2009).

[5]There are three member categories: full member, correspondent member, and subscriber member. Only full members can become P-members (participating members) in TCs and actively engage in committee work.

member bodies may assume leadership roles such as secretariat, chair, or convener. The secretariat, responsible for leading TCs, is managed by a member body volunteering for a specific period. It is also important to acknowledge that mere membership in a TC does not necessarily imply active participation. Meaningful engagement in negotiation processes depends on factors beyond formal membership, such as time and expertise (Alshadafan, 2020).

I.4 The StanDat database

StanDat is a database comprised of four parts; "Standards", "TC-membership", "Historical" and "Certifications", where each part contains 2-3 datasets individual datasets. Units and time series coverage varies across the datasets, as shown in Table I.1[6]. StanDat complements existing datasets like Nautos (formerly Perinorm), which focuses on national and regional standards, by providing detailed information on ISO standards' standardization process, historical development, and diffusion.

Due to ISO not possessing an API, the datasets are mainly derived from webscraping and parsing of ISO's webpages, with some information extracted from Excel and PDF files from their official archive. Detailed data gathering methods are described in Appendix A.0.1.

Web scraping is the practice of detecting and extracting information from the HTML-pages, and parsing involves structuring information into a dataset. Despite its growing adoption across various social science disciplines (Luscombe et al., 2022), to the best of my knowledge, this method has not yet been employed to construct a large-scale database of the type described here. Examples of previous use include using web scraping to collect data for specific research questions (Boeing & Waddell, 2017; Cavallo, 2018) and introducing frameworks on how to use web scraping to collect data on specific topics (Anglin, 2019; Braun et al., 2018). These are useful contributions, but come with some limitations in terms of data accessibility. The first examples do not always provide replication data, and the latter necessitates technical proficiency (Manovich, 2012). In contrast, the approach presented here focuses on improving data accessibility to the wider research community, showing not only how a large scale database can be built through web scraping and parsing, but also simplifies data access without requiring technical expertise from individual users.

[6]The codebook is available in Appendix A.

Category	Datasets	Time series	Description	Source and method
Standards	Status, SDGs, Lifecycle	1951 - 2023	Data on specific standards, e.g host TC, life cycle, current status, edition, pages, sustainability goals and ICS code.	www.iso.org with sublinks to every standard. Collected using webscraping.
TC-membership	Countries, Organizations	2002/4 - 2023	Data on membership in technical committees and subcommittees, for national member bodies and organizations.	Wayback Machine. Collected using the Wayback Machine API to scrape data.
Historical	Membership, Technical committees	1947 - 2015	Membership in ISO over time, including type of membership and function of membership, and year of establishment for various TCs.	www.iso.org. Parsed from pdf in public archive (see Appendix). TC establishment scraped from webpage.
Certifications	Per country, Per industry, Per country and industry	1993 - 2020 (but varies depending on ISO series)	Certification of ISO standards. The annual ISO survey documents the number of certifications reported by certification bodies accredited by the International Accreditation Forum per country, industry and ISO series.	The ISO Survey. Parsed from excel files.

Table I.1: Overview of the StanDat database.

In essence, StanDat is created through three different procedures. The first procedure collected data for the "Standards" datasets (first row in Table I.1), and involved scraping information on all standards that ISO lists on their webpages. This entails "classic scraping" of contemporary (not historical) webpages, and consisted of three steps; downloading the webpages to a local folder, extracting the relevant information from the webpages, and parsing this information into dataframes. Because ISO lists all standards ever produced on their webpages, the first standard in the "Standards" datasets is dated to 1951.

The second procedure addresses a common shortcoming with webscraping – that webpages are momentary snapshots susceptible to changes. This is the case with the "TC-membership" data; ISO only lists current TC members on their webpage, not past constellations. To address this temporal challenge, the Wayback Machine, managed by the nonprofit Internet Archive, provides a solution (Arora et al., 2016). Utilizing archived webpages enables researchers to retrieve and organize historical information, facilitating the collection of time-series data that might be absent from contemporary webpages[7].

Information gathered from the Wayback Machine is limited in two senses. First, the timeseries is limited to the organization's acquisition (and continued ownership) of the domain name. Since ISO bought their domain in 2002, this marks the beginning of the "TC-membership" datasets. Second, due to the Wayback Machine's selective archival, all relevant webpages are not available for every year. Around 28 percent of the units required imputation. The imputation process was rule-based; detailed in Appendix A.0.1 and validated in Appendix A.0.2. While data is available from 2002, it is recommended to use data from 2004, when there were enough snapshots to scrape sufficiently and make valid imputations.

Data validity is evaluated by assessing the correspondence between StanDat and information collected from other sources, including public documents and the United States' standardization organization ANSI. There are two types of possible error; imputing a country wrongly, leading to a false positive, and failing to observe a country membership, leading to a false negative. To quantify the validity, I employ accuracy as a metric. This metric refers to the correctness of values, here being how close the imputed values are to the reported values in the public documents. Accuracy calculates the ratio of correct observations to total observations, inclusive of false positives and negatives. The average accuracy on the time series excluding year 2002 is 88,82 [8], indicating that nearly 90 percent of the country-TC-years were correctly recorded. While this highlights an inherent uncertainty within the TC-membership dataset, the amount of bias due to wrong imputations is likely to be low since there is

[7]Blind and von Laer (2022) demonstrated the feasibility of using the Wayback Machine to gather information on TC membership, applying it to a smaller sample for their analysis.

[8]The average accuracy including year 2002 is 76,83.

no systematicity in which countries' webpages the Wayback Machine records or skips. Moreover, an accuracy of almost 90 percent is quite good compared to other similar imputation efforts (Hu & Tsai, 2022).

The third procedure involved parsing of other file formats, namely PDF and Excel. The "Historical" datasets are parsed from a PDF file in ISO's archive, last updated in 2015. For the "Certifications" datasets, I organized information from the ISO Survey, involving thorough cleaning, structuring, and merging of Excel sheets. The ISO Survey counts the annual number of valid certificates issued by certification bodies that have been accredited by members of the International Accreditation Forum (IAF)[9]. It is important to note ISO's disclaimer when using the "Certifications" datasets: *The ISO Survey is not a database. The providers of the data are the certification bodies accredited by IAF members and they participate on a voluntary basis. The level of participation fluctuates from one edition of the survey to another and can impact the survey results especially at the country level. Interpretations of the r esults and any conclusions on the trends should be made with these considerations in mind.*

Concerning ethical aspects, given its novelty, web scraping lacks a direct legal framework, although an emerging body of literature addresses its ethical considerations, such as bias, privacy, and confidentiality (Krotov & Johnson, 2023; Krotov et al., 2020). Adhering to these ethical guidelines and respecting web crawling limitations outlined in ISO's *robots.txt* document, I ensure compliance. Data is sourced exclusively from publicly accessible sources, not ISO's internal archives. Furthermore, practices include spacing out web requests and storing webpages locally, mitigating server load and enhancing reproducibility.

I.5 Applications of StanDat

The StanDat database can aid the research into standards and standardization in three important ways. First, it makes data directly available, simplifying the making of descriptive statistics. Second, it can be used to assess the scope conditions of findings from previous studies, providing insights into when and why phenomena occur. Third, because StanDat can be merged with other datasets, it can be used to explore new patterns and relationships with regard to international standards and other phenomena such as patents, global value chains, or, as demonstrated in section I.6, trade.[10]

[9] For more information, see www.iso.org/the-iso-survey.

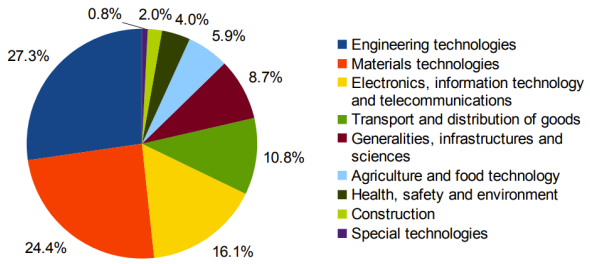
[10] While the below sections elaborate on these points, the StanDat database also has some constraints: the certification data is limited to selected standard series, there is no data on actors' perceptions of standards, and although TC membership data is available, the degree of participation is not specified.

I.5.1 Producing descriptive statistics

Descriptive statistics are a crucial element in both qualitative and quantitative research. StanDat offers a valuable repository of primary descriptive data, replacing previous reliance on secondary sources.

For example, Ruwet (2011), in a study on ISO's shift from producing physical standards to producing standards that also regulate societal issues, includes a graph on the distribution of ISO standards by technical sector, shown in figure I.2. Such descriptive data enriches the study, but there are also some limitations due to data scarcity; the graph is gathered from ISO's 2007 annual report, thus being a few years older than the publication, confined to percentages, and does not show development over time. Since StanDat provides more recent and versatile data, it can be used to produce for example figure I.3, showing cumulative growth of ISO standards across technical sectors from the organization's beginning. StanDat can also be used to tailor descriptive data more closely to the analysis at hand, for example such as figure I.4, which shows the increased establishment of technical committees within the new societal sectors that Ruwet (2011) highlights.

Figure 2. Portfolio of ISO standards and draft International Standards by technical sectors in the end of 2007



Source: ISO 2007 Annual Report, p.11
http://www.iso.org/iso/fr/annual_reports.htm

Figure I.2: Original illustration of proliferation and diversity of standards from Ruwet (2011).

In a different illustration, Rühlig (2023) explores diverse perspectives on the notion of technical standardization power, demonstrating China's progressive enhancement in this domain in recent years. One metric employed is the involvement in TCs, illustrated with membership data gathered from AFNOR. StanDat can be used to delve deeper into this metric, offering insights into specific sectors where China's influence has seen notable growth. While prior studies often emphasize China's ascendancy in information

[11] Sectors in figure I.2 and figure I.3 correspond approximately due to ISO changing sector categories in 2017.

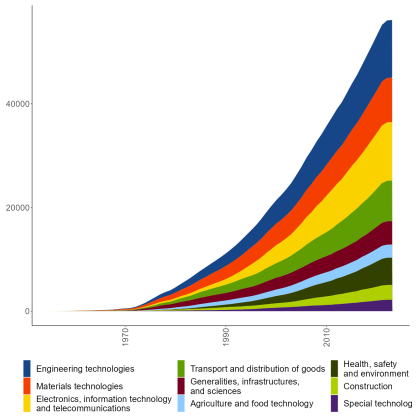


Figure I.3: Illustrating the proliferation and diversity of standards (Ruwet, 2011). Cumulative count of standards over time disaggregated by sector, 1950 - 2023.[11]

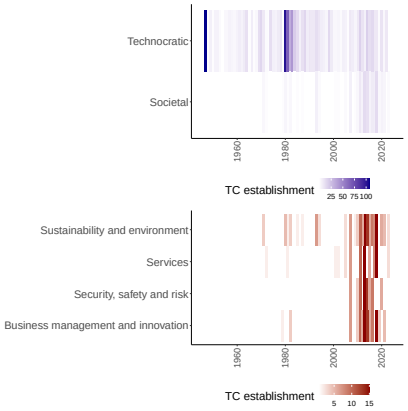


Figure I.4: Illustrating ISO's shift towards making standards on societal issues (Ruwet, 2011). Establishment of technical committees within technical and societal issue areas, 1950 - 2023.

technology (M.-j. Kim et al., 2020), figure I.5 illustrates that China's P-membership in TCs has surged or remained high relative to other active countries across all sectors. This poses an interesting pattern, and highlights the potential of StanDat as a valuable resource for assessments of standardization power.

I.5.2 Assess scope conditions

The encompassing data in the StanDat database enables researchers to evaluate the scope conditions of prior studies on standardization. For instance, much research has been devoted to the causes and outcomes of ISO certification. Scholars have studied questions such as why ISO certifications spread (Sampaio et al., 2011), whether certification improves business performance (Chow-Chua et al., 2003; Link & Naveh, 2006) or product innovation (Manders et al., 2016), or why firms want to pursue certification in the first place (S. W. Anderson et al., 1999). Many of these studies use surveys, often relying on the ISO Survey (Sampaio et al., 2009). Since data from the ISO Survey is only semi-structured and cumbersome to use, StanDat improves data accessibility by providing a portal to parsed and clean timeseries data. With this, scholars can quickly access ISO Survey data to extend previous analyses, and also compare ISO certification within a specific standard with other standards, as illustrated in figure I.6.

This availability simplifies analysis considerably, enabling researchers to investigate whether trends observed in the certification of earlier ISO series are consistent with

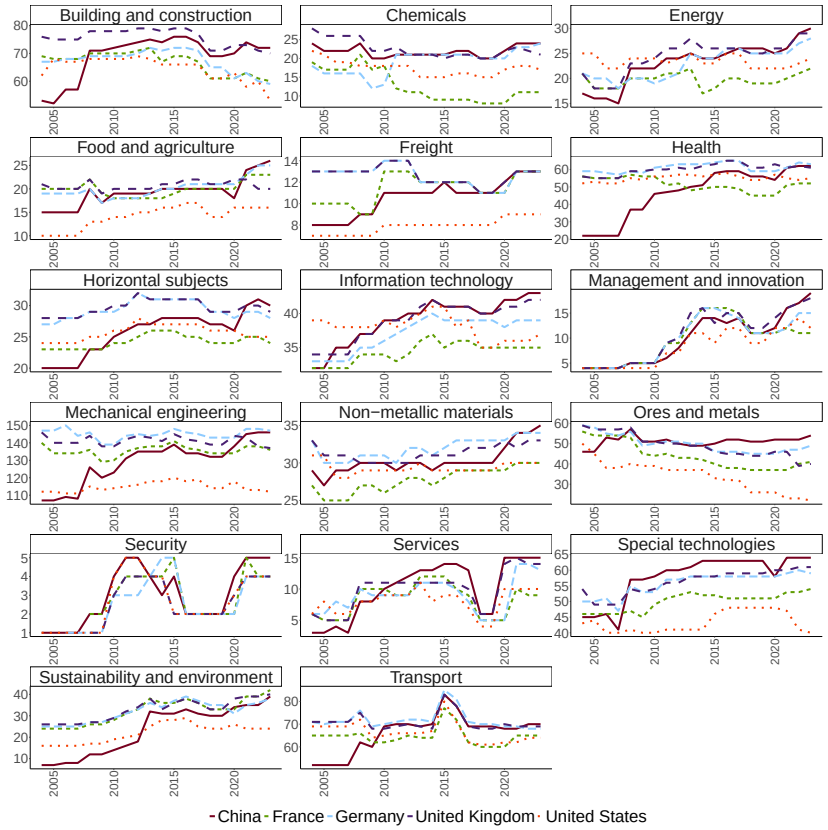


Figure I.5: P-membership in technical committees (TCs) and subcommittees (SCs) in the period 2004-2023 for the most active countries as noted by (Rühlig, 2023).

those of recent ISO series. For example, using a sample of 63 countries, Corbett and Kirsch (2001) and Vastag (2004) found that certification in Quality Management was an important predictor for certification in Environmental Management. Using StanDat, these studies can be extended to broader time frames, new ISO series, and more countries. This is demonstrated in an analysis in Appendix E, which, while significantly broadening the scope, largely supports the original findings. Moreover, previous ISO certifications can predict current ISO certifications, even across different topics. Quality Management certification can predict Environmental Management certification, which, in turn, can predict certification within Information Security Management. Overall, this provides valuable insights into how and why standards proliferate, even across changing technological and geopolitical circumstances.

In addition to extending older analyses, StanDat can be used to test the scope conditions of qualitative findings. For instance, Werle and Iversen (2006) argue that in

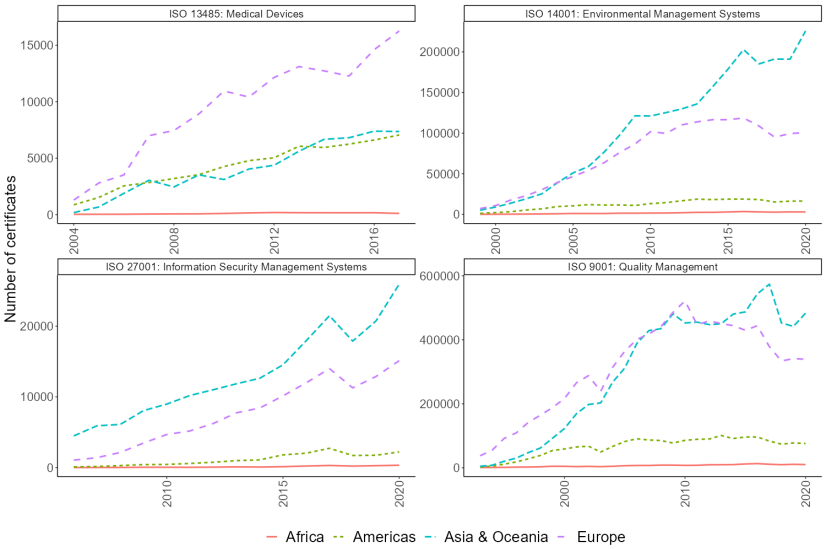


Figure I.6: Number of valid certificates issued by IAF accredited certification bodies per year for selected ISO standard series, various time series.

standardization processes, output legitimacy is more important than input legitimacy. Rühlig (2023) examines Chinese technical standardization power, providing a framework to understand standardization power which, when combined with the more general works of Blind and von Laer (2022) and Ding (2024), can be used to assess technical and scientific power among a broader set of countries. StanDat can thus be a resource for researchers aiming to evaluate the validity and reach of such theories.

I.5.3 Provide new analyses

Lastly, the StanDat database can contribute to new analyses within the topic of standards and standardization. In particular, because the StanDat database can be merged with other datasets, scholars can expand on studies investigating the relationship between standardization and related concepts such as economic growth, legitimacy, global value chains, membership in international organizations, foreign direct investment and innovation. A few suggestions to topics, possible research questions, general literature and compatible datasets are given in table I.2. In Appendix A.0.4, I provide an example of such an analysis, demonstrating that membership in ICT related TCs is significantly correlated with patents output in the same technologies, although with no significant difference between P-members and O-members. Section I.6 is further dedicated to a new analysis.

There are numerous potential datasets for merging, with a primary identifier being

country-year. Additionally, utilizing concordance tables (for example as provided by Blind (2004, p. 349)), researchers can match standards' ICS codes with other entities based on shared keys such as patents IPC codes, industry ISIC codes or trade SITC codes.

I.6 Standardization and trade networks

This section showcases StanDat's applicability in providing new analyses by expanding on an important topic; that of standardization and trade. In doing so, the study follows up on the expanding literature on the effects of standards on trade (see e.g. Yang (2023)). Previous studies has found a generally positive relationship between adoption of international standards and trade (Knut Blind & Ramel, 2018; Mangelsdorf, 2011; Swann, 2010). The positive relationship can be attributed to the fact that adopting a standard may signal openness, quality and safety to exporters, as well as enabling exporting countries to adapt their products to foreign markets (Clougherty & Grajek, 2014). However, adopting an international standard is not without downsides – it can be costly, especially when an adopter has had little influence on the standardization process (Blind, 2001).

This last observation shifts the question from the trade effect of *adopting* standards to the effect of *producing* standards. Büthe and Mattli (2011a) point out the importance of having influence in the standardization process, in particular how early participation in the standardization process allows countries to shape standards according to their needs. A growing body of literature has studied the factors explaining standardization involvement among firms (Blind, 2006; Riillo, 2013), and an emerging literature is investigating the involvement of national standard bodies in international standardization fora (Blind & von Laer, 2022; Mattli & Büthe, 2003). In particular, an advantage of participating in the standardization process for trade lies in the capacity to share knowledge efficiently and swiftly. Thus, joint participation in TCs may positively influence bilateral trade through several mechanisms; signalling openness to other countries, enhancing efficient and need-specific harmonization and enabling knowledge sharing within specific technologies.

Drawing inspiration from recent research in international relations that explores how networks reveal interdependence among international actors, this section investigates the relationship between joint TC membership and trade volumes through networks. International networks facilitate flow of resources like money, goods, or information, while also shaping and constraining the power of actors based on their connections and relative positions within these networks (Farrell & Newman, 2019). Examining the correlation between standardization networks and trade networks acknowledges the "complex interdependence" of networks, as highlighted by Keohane and Nye (1977). Researchers have investigated how trade networks interact with other networks such as

Research Topic	Examples of Research Questions	Background Literature	Complementary Datasets
Economic growth and standards	Does TC membership stimulate economic growth? Does ISO membership contribute to economic growth? How does certification relate to economic growth in emerging economies? To what extent is intra-industry trade prevalent among joint TC members? Are PTAs more common among joint TC members?	Blind and Jungmittag (2008), Ding (2024), and Swann (2010)	*World Bank Development Indicators (WDI)*, Graham and Tucker (2019), *UN Comtrade*, *WTO Dispute Settlement Data*
Legitimacy of standards and standardization	What role do stakeholders play in legitimating standards? How do multi-stakeholder standardization processes influence standardization speed? Are abstracts for societal standards more similar to treaties texts than physical standards?	Bernstein and Cashore (2007), Mena and Palazzo (2012), and Ruwet (2011)	*United Nations Treaty Collection*, *Factiva*, *NexisUni*, *Global Newsstream*
Global value chains (GVCs) and standards	Are countries linked by GVCs more likely to join the same TCs? Does participation in TCs boost a country's integration into GVCs?	Baglioni et al. (2020) and Nadvi (2008)	Mancini et al. (2024), *Trade in Value-Added (TiVA)*, *Global Value Chain (GVC) Indicators*
ISO membership	What are the regional differences in the production of international standards? How have historical events, such as financial crises, impacted ISO membership? What has led developing countries to seek ISO membership?	Jansen (2010) and Louis and Ruwet (2017)	*Correlates of War Intergovernmental Organizations (IGO)*, Graham and Tucker (2019)
Tariffs and standardization	Does joint TC membership increase dyad-wise tariff liberalization? What impact does ISO certification have on tariff liberalization?	Baccini et al. (2018)	Baccini et al. (2018), Harvard Dataverse V1
Foreign direct investment (FDI) and standardization	Is ISO certification associated with more FDI? Does joint TC membership lead to increased FDI? Does ISO membership or membership in multiple TCs correlate with increased FDI?	Chen et al. (2014) and Clougherty and Grajek (2008)	*OECD Global FDI flows*, *World Bank Development Indicators (WDI)*
Innovation and standardization	Is there a positive relationship between industry-wise TC membership and patents? What is the relationship between R&D, patenting and standardization participation? In which regions do national patents tend to precede international patents?	Blind et al. (2023) and Frietsch and Schmoch (2010)	*Perinorm*, *World Intellectual Property Organization (WIPO)*, *OECD Research and Development Statistics*, Toole et al. (2021)

Table I.2: Examples of research topics combining StanDat with complementary datasets.

migration (Sgrignoli et al., 2015), alliance building (Haim, 2016), militarized conflict (Kinne, 2012) and financial integration (Schiavo et al., 2010). These studies suggest that network constitutions in trade matters for the composition of other networks.

The global standardization network represents flow of information. Assuming that countries must both provide and receive information to reap the benefits of this network, the network consists of P-members connected by common TC membership, illustrated in figure I.7. Each member body sends experts to their respective TCs, where the experts deliberate on producing standards that, in turn, regulate global interactions and transactions, one of them being trade[12].

Table I.4 presents various models examining the relationship between a directed dyads' TC connections and bilateral trade[13]. Both dependent and independent variables are logged, reflecting the assumed declining utility of accumulating one extra unit of respectively TC connections and trade. The models rely on the gravity model (Salette & Tinbergen, 1965) to control for trade confounders. Reflecting recent advances in the trade economics literature using the gravity model, the models utilize high-dimensional fixed effects, incorporating fixed effects on dyads, countries and years (J. E. Anderson, 2011), a method recently used by for example Carter and Poast (2020).

The models employ progressively more controls, detailed in Table I.3, but with shorter time series. "Gravity" controls stem from the gravity model, targeting size and proximity. In the high-dimensional fixed effects specification, conventional Gravity controls such as GDP and capital distance are subsumed by the dyad fixed effects and country-year fixed effects. The "Gravity+R&D" model includes a measure of R&D intensity as patents per GDP. Since R&D intensity may be a mediator, the next models exclude this variable, but adds controls beyond the gravity framework. The "Gravity+" control set expands on "Gravity", including dyad regime similarity, preferential trade agreements (PTAs) and common currency. The "Gravity++" controls encompass the "Gravity+" controls plus indicators for neighboring states' strategic rivalry and engagement in alliances. Tables displaying coefficients of control variables can be found in Appendix table A.5.

Table I.4 shows patterns in alignment with previous findings regarding the positive relationship between standardization and trade. Frequent TC connections correlate positively and significantly with trade. From the baseline model alone, increasing a dyad's TC connections by one percent is indicative of a seven percent increase in bilateral trade volumes. These results are mostly stable throughout various model

[12]This measure is a proxy for participation, but it does not measure it directly. Formal participation in a TC does not always entail practical participation by the national member body's delegates (experts) (Alshadafan, 2020).

[13]When constructing the network, countries participating in no shared TC are not mapped. Thus, using the Comtrade data as a baseline, dyads with missing TC connections were assumed to have no connection. Both measures are log transformed to reflect the assumed declining marginal benefit of one extra unit of overlapping TC membership.

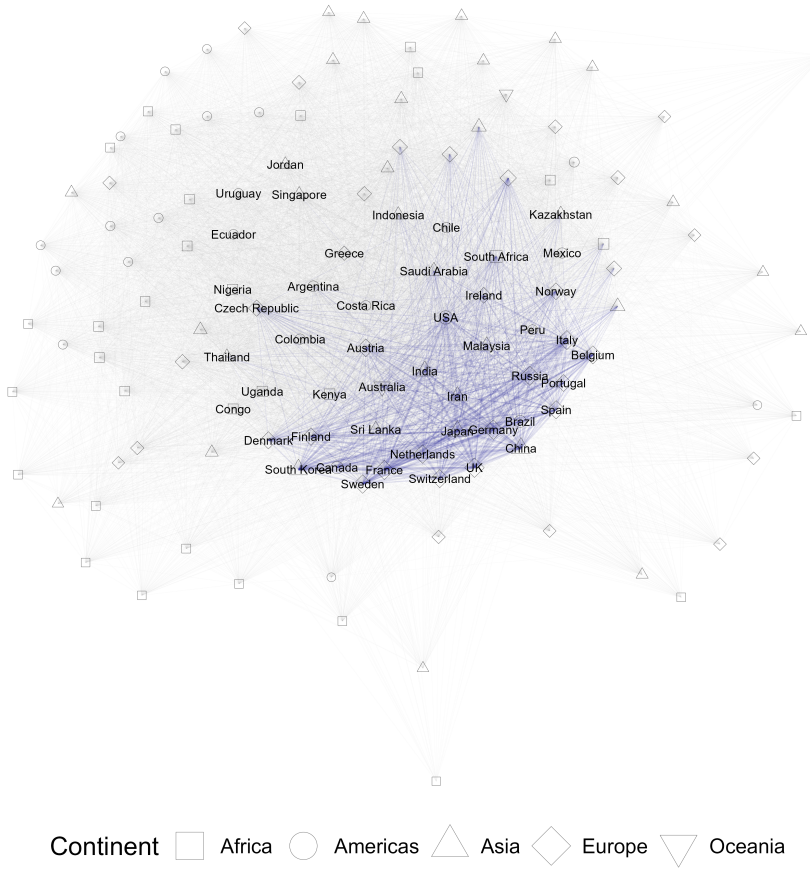


Figure I.7: Countries sharing P-membership in technical committees, 2022. The size of the node indicates how many TCs the country participates in. A link between the nodes means that the countries participate in the same TCs. The size of the link indicates how many TC seats the countries share.

specifications, including using alternative measures of trade, using a binary independent variable, and easing the fixed effect dimensionality to assess the restrictiveness of the model (see Appendix A.0.5).

Model	Control variables	Source
Gravity	Regional trade agreement	CEPII Gravity Database (Conte et al., 2022)
	WTO member dyad	
Gravity+R&	Patents as share of GDP	PatentsView (Toole et al., 2021)
Gravity+	Democratic dyad (polyarchy > 0.4 = democratic)	Varieties of Democracy (Coppedge et al., 2024)
	Preferential trade agreements (PTA) in dyad	DE Database (Dür et al., 2014)
	Common currency	de Sousa (2012)
Gravity++	Alliance	Correlates of War (Gibler, 2009)
	Strategic rivalry dyad	Miller (2019)

Table I.3: Control variables in table I.4.

	Dependent variable: ln(Dyadic trade) (UN Comtrade)				
	Baseline	**Gravity**	**Gravity+R&D**	**Gravity+**	**Gravity++**
ln(TC connections)	0.073***	0.084***	0.057***	0.036*	0.031
	(0.014)	(0.017)	(0.013)	(0.016)	(0.019)
Num. Obs.	402 385	346 684	229 574	190 173	125 511
RMSE	1.38	1.38	1.26	1.25	1.14
Controls	No	Gravity	Gravity+R&D	Gravity+	Gravity++
Time series	2004-2022	2004-2021	2004-2021	2004-2015	2004-2011

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Fixed effects by dyad, country and year, clustered standard errors by dyad and year.

Zero imputation on dyads with missing on TC connections.

Gravity controls: GDP, population, distance between capitals, common language, regional trade agreement, WTO dyad.

Gravity+R&D controls: Adds to Gravity patents per country.

Gravity+ controls: Adds to Gravity+ democratic dyad, preferential trade agreement, common currency.

Gravity++ controls: Adds to Gravity++ strategic rivalry, alliance.

Table I.4: Relationship between dyadic TC connections and trade volume.

However, three points should be made. First, the significantly positive coefficient becomes insignificant when adding the last set of control variables. Sensitivity checks suggests that this is not due to the shorter time series, indicating that the relationship may be partly driven by other factors, such as the goodwill of democratic dyads or alliances (see Appendix table A.14). Second, when controlling for R&D intensity, the TC coefficient remain significant and strong, suggesting that knowledge advantages gained from joint TC membership in terms of trade may operate partly through R&D intensity. However, this relationship is rather sensitive, as removing zero imputation on missing dyads from the standardization network renders the coefficient on "Gravity+R&D" insignificant (see Appendix table A.12). Third, and importantly, although these models include multiple controls to account for possible confounders, the model cannot rule out reverse causality. For example, while information sharing could facilitate trade, large trade volumes may also incentivize countries to participate in the same TCs to influence standardization procedures. Robustness checks using GMM models indicate that there is no clear causal direction from joint TC membership to larger trade volumes (see Appendix table A.15). A research approach designed for causal inference is necessary to delve deeper into this matter.

With these caveats in mind, the analysis nevertheless shows a rather robust relationship between TC connections and trade volumes, indicating that participating in standardization networks with other countries matter for bilateral trade. This relationship may partly stem from advantages in harmonizing expectations when countries have first-mover advantages in standardization, as noted by Büthe and Mattli (2011a). Further, countries may signal openness, safety and quality in trade by participating in standardization (Clougherty & Grajek, 2014), and participation may enhance knowledge sharing, boosting R&D efforts and trade. Overall, this study supports the notion of complex interdependence in global markets, in which trade patterns seem to matter for a range of other network constitutions.

I.7 Conclusion

In the international political economy, standards are important regulatory tools, setting guidelines ranging from the size of containers to the definition of "quality". This paper aims to boost the growing literature on standards and standardization by presenting a new database, StanDat, constructed from information provided by the International Organization for Standardization (ISO). By doing so, this study also gives insight into the process of producing comprehensive databases when there is a lack of adequate data from other sources, countering availability bias on marginal topics in the social sciences (Mahrt & Scharkow, 2013).

The StanDat database can be used by qualitative and quantitative scholars alike, either to produce descriptive statistics, assess scope conditions of previous findings, or

contribute to new analyses. For example, by utilizing the StanDat database along with UN Comtrade data, this article finds support for the notion of complex interdependence in global markets, namely that countries which frequently participate in standardization processes together also trade more, although the causality of this relationship may go either way. Further examples of important questions encompass the legitimacy and efficiency of standards, or how standards relate to for example global inequality or climate change. Because of the interdisciplinary of the standardization literature, the StanDat database can be relevant for a wide set of scholars.

While the StanDat database is composed of ISO standards only, several other standardization organizations exist. The methodologies illustrated in this paper, encompassing data collection, tidying, and dissemination, are applicable to these entities as well as numerous additional sources of data within the realm of social sciences. If data is publicly available on the internet, this paper demonstrates the viability of transforming that into research data.

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Paper II

Legitimation Strategies of Transnational Private Institutions: Evidence from the International Organization for Standardization

Solveig Bjørkholt

Abstract

Transnational private institutions (TPIs) operate at the intersection of technocratic efficiency and democratic accountability, raising questions about their choice of legitimation strategies. This study tackles these questions by analyzing the legitimation strategies of a prominent TPI, the International Organization for Standardization (ISO), as it expanded its portfolio towards societal issue areas. By employing on a two-dimensional model gathered from the literature on international organizations, and a novel dataset on ISO standardization, the study reveals that ISO's legitimation strategies are sensitive to the type of issue each standard aims to regulate. These insights reinforce the notion that issue areas shape TPIs' legitimation strategies. Furthermore, contrary to previous models on the legitimation strategies of TPIs, this study finds that democratic and technocratic legitimation are not synonymous with input and output legitimation, but that both legitimation strategies occur across input and output phases of the standardization process. Thus, this study highlights the utility of an expanded conceptualization when examining the legitimation strategies of TPIs, particularly as many of them increasingly engage in the regulation of societal issues.

II.1 Introduction

The year 2010 concluded what has been called "the largest stakeholder consultation on social responsibility ever held"(ISO, 2017). Hosted by the International Organization for Standardization (ISO), hundreds of representatives from corporations, NGOs and government institutions negotiated a global standard providing guidance on what social responsibility entails (ISO 26000) (Mena & Palazzo, 2012). This multi-stakeholder process, being unorthodox for ISO, was partly held in response to criticisms of having an institution driven by technical experts produce standards on societal issues (K. Hallström, 2008). Consequently, scholars have interpreted this process as a legitimization strategy, specifically one which emphasizes democratic values like representativeness and inclusivity over technical expertise (Hahn & Weidtmann, 2012).

The case of ISO showcases how transnational private institutions (TPIs), though often being known and commended for their technical expertise, utilize democratic legitimation strategies such as multi-stakeholder processes (Boström & Tamm Hallström, 2013; de Bakker et al., 2019; Mena & Palazzo, 2012; Moog et al., 2015; Schleifer, 2019). Yet, despite these observations, compared to the literature on international organizations (Dingwerth et al., 2020; Schmidtke & Lenz, 2023; Schmidtke et al., 2023; Sommerer et al., 2022), the study of legitimation strategies among TPIs has been slow to emerge (Diprose et al., 2019; Schleifer, 2019). In this article, I draw on the case of ISO and the literature on international organizations to explore how scholars can study variation in legitimation strategies employed by TPIs. As such, the article contributes to the literature in three distinct ways.

First, the literature on TPIs often conceptualizes legitimation in terms of input and output legitimation (Dingwerth, 2007; Richardson & Eberlein, 2011; Risse, 2006; Scharpf, 1999). However, this one-dimensional approach tends to conflate democratic legitimation solely with input legitimation, overlooking the fact that democratic legitimation can also occur during the output phases of a process. For example, the quote introducing this article is from ISO's own webpage, and can be interpreted as a democratic justification of the ISO 26000 project in its output phase. Arguing that technocratic and democratic sources of legitimacy constitute a separate dimension, I draw on a two-dimensional conceptualization of legitimation strategies from the literature on international organizations (Tallberg & Zürn, 2019). I propose that this framework is more effective for examining legitimation strategies among TPIs. Using ISO as a case study, I demonstrate the viability of this model.

Second, utilizing novel data, I broadly analyze patterns of ISO's policy expansion, in which ISO moved from focusing on exclusively technical standards to increasingly also producing standards on societal issues (Ruwet, 2011). By doing so, this study empirically assesses a theoretical framework that identifies issue area as a determinant of various legitimation strategies among TPIs (Bernstein, 2011). This theory is

particularly relevant given observations that TPIs are playing an increasing role in regulating societal issues such as human rights, labor protection, and environmental considerations (Bartley, 2007; Boström & Tamm Hallström, 2013). Since ISO has internally transitioned from focusing exclusively on technical standards to increasingly producing societal standards, this case provides a unique opportunity to control for organizational context while varying the issue area, thus serving as a useful case to examine the proposed hypothesis.

Third, while previous empirical research into the legitimacy and legitimation of ISO standards has mostly been focused on single standard-series (e.g Hahn and Weidtmann (2012), Tarí et al. (2012), and White (2021)), this study uses large-N data on ISO's standard portfolio to study the connection between policy expansion and legitimation strategies. This mapping of societal and physical standards indicates that ISO's use of democratic legitimation is not only limited to prominent societal standard series such as ISO 9001, ISO 14001 and ISO 26000, but extends to standards in general that aim to regulate societal issues.

Overall, this article shows that a two-dimensional understanding of legitimation strategies is well suited to understand how ISO may shift between democratic and technocratic legitimation strategies, both input and output, when producing standards on societal and physical issues respectively. I argue that this theoretical framework spans broader. Given that ISO is usually considered a typical example of a TPI, it would be beneficial to investigate this framework for other TPIs as well.

II.2 Sources and tension of legitimacy in transnational private governance

ISO's authority falls under the rubric of transnational private governance. This area constitutes non-state actors that make and implement norms and rules beyond the state. The category of private actors is broad, including for example business associations, federations of trade unions, multi-national corporations, learned societies, standard-setting organizations, think tanks, religious orders, sporting organizations and environmental groups (Ronit & Schneider, 2000). Yet, while the category of non-state actors is diverse, they seldom operate alone when engaged in governance on a global level. Non-state actors' potential for exerting global governance is mainly manifested through transnational private institutions (TPIs) (P. Pattberg, 2004)[1].

[1] P. Pattberg (2004, p. 55) defines transnational private institutions (TPIs) by their informal collaborations, rule-making focus, diversity of actors in networked constellations and focus on bridging profit and non-profit sectors to jointly sustain global public goods. Risse (2006, p. 4) defines TPIs by two properties: (1) their inclusion of non-state actors or non-governmental organizations (NGOs) into governance arrangements and (2) their emphasis on non-hierarchical modes of steering.

These institutions have grown to sustain a large portion of global regulations over the past decades (Bartley, 2022; C. A. Cutler, 1999).

Like the actors they organize, TPIs are a diverse group regulating a host of different issues. For example, the Forest Stewardship Council (FSC) has produced standards for sustainable management of forests, and the Marine Stewardship Council (MSC) for sustainable fisheries (Dingwerth, 2017; P. H. Pattberg, 2005). In the financial field, the Basle Committee on Banking Supervision sets standards for banking regulation (Tsingou, 2007), and the security field has seen an emergence of private military firms and security experts (A. C. Cutler, 2010). Private actors such as the Internet Corporation for Assigned Names and Numbers (ICANN) are active in the field of internet governance (Take, 2012). Standard-setting bodies are also typical examples of TPIs (Peña, 2015; Thirkell-White, 2006), even having been called "the most common example of private rule making" (P. H. Pattberg, 2005, p. 359). The most prominent global standard-setters are the International Accounting Standards Board (IASB), the International Electrotechnical Commission (IEC) and the International Organization for Standardization (ISO). Among these, ISO has the most generalist focus (Büthe & Mattli, 2011; Donnelly, 2007).

Although TPIs differ in many respects, they share a common characteristic: their operations are not mandated by national or international law, despite their role in setting rules that govern international interactions (Black, 2008). These rules are often defined as "soft law" because they are voluntary and derive authority from the recognition of social expectations rather than being legally binding (Kerwer, 2005; Ruggie, 2007). They include for example certification systems, reporting guidelines, eco-labels, and management standards (P. H. Pattberg, 2005)[2]. The characteristics of TPIs as creators of soft law driven by constellations of private actors have led scholars to note how TPIs may rely on distinct sources of legitimacy (Macdonald & Macdonald, 2017; Nölke & Graz, 2007).

The subject of legitimacy in international governance has garnered substantial scholarly attention over the past years (Bodansky et al., 2013). Many questions abound, including how legitimacy may stem from various sources, for example expertise or representation (Dellmuth et al., 2019). Here, TPIs can be said to face a particular challenge. TPIs are, on one hand, often founded on, and draw legitimacy from, their expertise on complex fields (Tsingou, 2007). Many arise in response to "government gaps" (Dingwerth, 2017, p. 77), specifically due to "governments' lack of requisite technical expertise, financial resources, or flexibility to deal expeditiously with ever more complex and urgent regulatory tasks" (Büthe & Mattli, 2011, p. 5). As noted by

[2]Even though the rules set by TPIs are not legally binding, they can become more or less binding in social terms, for example if corporations risk their reputation for not implementing sustainability standards (Beisheim & Dingwerth, 2008). Dingwerth (2007, p. 7) defines the rules set by TPIs as deliberate and specific instructions for behavior whose normative authority warrants at least a minimum level of compliance.

Delbrück (2003, p. 42), "[e]fficiency can have a legitimizing effect". In this view, the legitimacy of TPIs stems from their ability to accomplish policy tasks, and legitimacy is maintained through effective problem-solving by providing expertise on relevant issues. This can be called a technocratic form of legitimacy.

On the other hand, effectiveness is not the only relevant criteria for legitimacy, and TPIs have often been criticized for their lack of democratic legitimacy (Dingwerth, 2007; Koenig-Archibugi & Macdonald, 2013; Richardson & Eberlein, 2011). Because private governance initiatives have no basis in democratic states, there is no option for citizens to participate in rule-making or vote incompetent rulers out of office (Risse, 2006). As such, TPIs fail to meet ideals of representation and accountability. Furthermore, with no foundation in international legal frameworks, they cannot be held judicially accountable through established legal channels (Black, 2008).

Many TPIs rely on both technocratic and democratic legitimacy (Auld et al., 2015; Durocher et al., 2019), but balancing these can be challenging[3]. Ideals of broad participation and transparency in negotiations can conflict with ideals of decision-making efficiency (Ruggie, 2007). As noted by Koppell (2010, p. 3), "[i]ncluding a broader range of constituencies is normatively and politically appealing, but it obviously will not speed up the standard-generating process." Peña (2015, p. 62) describes this as a "legitimacy-effectiveness trade-off", where involving many participants in decision-making complicates consensus and collective action. Increased representation and transparency can also lead to more demands from other stakeholders (Boström & Tamm Hallström, 2013). Additionally, including diverse stakeholders often requires less technical discussions, which challenges technocratic legitimacy.

II.3 Legitimation strategies in transnational private governance

A legitimation strategy can be defined as a goal-oriented activity that aims to establish, build and maintain support among core stakeholders (Tallberg & Zürn, 2019). Legitimation strategies rest on the concept of sociological legitimacy, which centers on an audiences' belief that an institution has the right to govern (Bodansky et al., 2013). Contrary to normative legitimacy, which assesses theoretical standards for what legitimacy entails, sociological legitimacy takes the empirical perception of stakeholders as the starting point. When an organization employs legitimation

[3]Some scholars argue that expert-based rule-making and participatory demands can be mutually reinforcing (e.g. Lindgren and Persson (2010)). Studies supporting this view often examine the EU, an intergovernmental and supranational entity with the power to create binding rules, and thus quite different from TPIs. In the EU, demands for democratic procedures are stronger, arguably making trade-offs in efficiency and technocratic precision more acceptable.

strategies, it aims to convince relevant audiences that their authority is normatively appropriate (Gronau & Schmidtke, 2016).

There is a long standing argument that what audiences consider normatively appropriate varies across contexts (Esty, 2006; Suchman, 1995). While there are multiple conceptual frameworks to classify this variation, I rely here on the flourishing literature on legitimation strategies of international organizations (Dingwerth et al., 2020; Schmidtke & Lenz, 2023; Schmidtke et al., 2023; Sommerer et al., 2022). This literature draws on the concept of "normative yardsticks" (Dingwerth et al., 2020, p. 5), which holds that actors base their evaluation of institutions' legitimacy on different criteria depending on context. Tallberg and Zürn (2019, p. 587) have for example argued that "[a]n institution such as the UN Security Council may fare poorly when evaluated against a specific normative standard, such as democracy, but still be broadly regarded as legitimate. Conversely, an institution such as the ICC may conform well to a specific normative standard, such as the rule of law, but still be regarded as illegitimate among some audiences."

Schmidtke et al. (2023) draw on previous literature to organize these normative yardsticks into "standards of legitimation". Here, technocratic legitimation standards justify rules in terms of functional capability, economic welfare and peace and security, and democratic (liberal) standards refer to democracy, human rights, rule of law and environmental protection[4]. Because the tension between technocratic and democratic legitimacy is particularly relevant for TPIs, and this analysis will focus on these two. The classification aligns with Fritz Scharpf's distinction between input and output legitimacy (Scharpf, 1999), which is a popular framework for assessing TPIs' legitimation strategies (Dingwerth, 2007; Richardson & Eberlein, 2011; Risse, 2006)[5]. Input legitimacy is typically associated with the participatory quality of decision-making processes. It encompasses criteria of democratic legitimacy, such as inclusion, representation, transparency, consensus, and procedural fairness. In contrast, output legitimacy is akin to technocratic legitimacy. It focuses on the problem-solving efficiency of established rules, highlighting aspects such as coverage, efficacy, and enforcement (Krahmann, 2017; Mena & Palazzo, 2012; Quack, 2010). Schmidtke et al. (2023) refer to input and output legitimacy as procedure and performance respectively (Tallberg & Zürn, 2019).

While the input-output framework is valuable in recognizing that legitimate systems rely on both democratic norms and problem-solving capacity, its one-dimensionality

[4]Schmidtke et al. (2023) includes elements like legitimation intensity and modes, which, while not central to this study, are necessary components of the legitimation concepts and are discussed in Section II.6.

[5]Many authors include throughput legitimacy, which considers the quality of decision-making processes, like equal voice and fair voting rules (Schmidt, 2013). However, because it shares criteria with input legitimacy, such as transparency and inclusiveness, I exclude it from the current framework for simplicity.

introduces certain weaknesses. By equating input factors with democratic legitimacy and output factors with technocratic legitimacy, the framework makes it more challenging to study the tension between various legitimation strategies across processes. This weakness was identified by Tallberg and Zürn (2019, p. 592), who note that "[p]rocedural standards may pertain to other qualities of the decision-making process than democracy, such as efficiency, legality, and expert involvement. Likewise, performance standards may pertain to other qualities than effectiveness, such as protection of democratic rights and processes". Research supports this conceptualization among international organizations, showing that citizens respond to technocratic and democratic legitimation in both procedures and performances (Dellmuth et al., 2019).

Thus, adding a dimension to the framework acknowledges that TPIs can employ various mixes of legitimation strategies across a process. This process perspective is illustrated in Table II.1, which is adapted from Tallberg and Zürn (2019). A TPI might prioritize democratic legitimation during the input stage and technocratic legitimation during the output stage, or focus on democratic legitimation throughout both stages. This framework helps to understand variation in TPIs' legitimation strategies. For instance, Krahmann (2017) shows that, when faced with challenges in measuring performance in areas like health and security, private actors often emphasize "performativity", effectively reframing democratic input factors as output factors. In the field of standards, Werle and Iversen (2006) observes that standardization organizations increasingly rely on democratic legitimation due to demands for openness, representation, and fairness as standards regulate more social aspects. However, because many stakeholders, like NGOs and developing countries, often lack the resources needed to participate in meetings, democratic input legitimacy becomes harder to achieve as stakeholder numbers grow. Consequently, standardization organizations emphasize democratic output legitimacy.

	Input / Procedure	**Output / Performance**
Technocratic	Expert advice; efficiency; legality	Problem solving; collective welfare gains; distributive fairness
Democratic	Participation; accountability; deliberation; transparency	Protection of rights; protection of the democratic process

Table II.1: Legitimation strategies of transnational private institutions, adapted from Tallberg and Zürn (2019).

II.4 Changing legitimation strategies in response to issue areas

One question that emerges is what type of contextual change TPIs respond to when changing their legitimation strategies. Previous research lists multiple possible drivers. Quack (2010), for example, proposes that demands from an audience for specific types of legitimation leads to changes. Building on this, Schleifer (2019) suggests two sets of mechanisms; internal mechanisms, including pressure from stakeholders and isomorphic pressures within organizational fields, and external mechanisms, including preferences of institutional entrepreneurs and processes of institutional bargaining between stakeholder groups. To study shifting legitimation strategies across processes, this study focuses on one prominent mechanism highlighted in the literature, namely that of issue area (Dellmuth et al., 2019; Dingwerth, 2017; Schleifer, 2019).

Theorizing the connection between issues and legitimation strategies, Bernstein (2011) proposes that legitimation requirements vary based not only on the explicit demands made by a TPI's audience, but also on the specific social structure it operates within. This latter point emphasizes that various social structures define different normative criteria for what is deemed appropriate. These norms are institutionalized through, for example, specific declarations and principles applying to a given sector, treaties, trade rules, action programs and statements of leaders. One of these social structures is the "[n]orms defining international political economy of an issue" (p. 26)[6]. In other words, specific norms are institutionalized according to issue area, leading to specific legitimation requirements. To give an example, Dingwerth (2017) argues that the presence or absence of state regulation within an issue can affect legitimation strategies, showing that when public regulation already exists within an issue, TPIs are more concerned with demonstrating the democratic qualities of their processes.

Thus, it is assumed that the specific issue a TPI regulates will influence its legitimation strategies due to established issue-specific norms. This is important as TPIs increasingly regulate more societal issues like labor, human rights, and the environment (Bartley, 2007). For example, Dingwerth (2017, p. 75) observes that the proliferation of TPIs has been particularly pronounced in the field of sustainability governance. Examples include the previously mentioned FSC and MSC, but also other TPIs such as the Global Reporting Initiative (GRI) (Levy et al., 2010) and the World Commission on Dams (WDC) (Dingwerth, 2005). Furthermore, a host of different private initiatives have been enacted to address global supply chains' adverse effects on labor rights and the environment (LeBaron & Lister, 2022; Locke, 2013), and a number of private corporate policies aim to combat human right violations (Buhmann

[6]Bernstein (2011) mentions two other examples of social structures, namely existing norms regarding delegation of authority, and a general growing demand for democratic global governance.

et al., 2019). The expansion of ISO into societal issues, as described in section II.5, is another example of such policy expansion.

While TPIs' expansion into societal issues has led to increased focus on the democratic legitimacy of TPIs (Dingwerth, 2007; Hale, 2020), legitimation strategies have received less attention. Yet, scholars have observed certain shifts towards democratic legitimation. For example, TPIs increasingly use multi-stakeholder processes to emphasize inclusivity and representation in their rule-making processes (Boström & Tamm Hallström, 2013; de Bakker et al., 2019; Moog et al., 2015; Schleifer, 2019). Among standardization organizations, IASB has shifted its focus from technical competence to increasingly direct attention to transparency, accountability and inclusivity following the financial crisis (Burlaud & Colasse, 2011; Richardson & Eberlein, 2011). ISO 26000, as described in the introduction, is another oft-cited example of TPIs' response to legitimacy concerns following shifting issue areas (Hahn & Weidtmann, 2012; K. Hallström, 2008; Heires, 2008; Peña, 2015).

II.5 Legitimation strategies across issue areas at ISO

The International Organization for Standardization (ISO) is a typical example of a TPI (Büthe & Mattli, 2011). Its members include mostly non-state actors organized through national standards bodies. These bodies represent the leading standardization entities within their respective countries and are typically private sector organizations (Mattl, 2003). They organize domestic representatives from various sectors, such as business, public sector, consumer groups, research groups, NGOs, accreditation firms and trade unions. Through the membership of their national standards body, these representatives participate in various technical committees (TCs) at ISO, where they negotiate standards.

ISO standards are examples of private transnational regulation. They are defined as "rules for common and voluntary use which structures interaction and represents the values against which people, practices and things are measured" (Botzem & Dobusch, 2012; Brunsson et al., 2012; Loconto & Busch, 2010). When standards are not implemented in law or widely dispersed in a given market, adopting them is in practice voluntary and as such, dependent on legitimacy.

ISO's legitimacy is closely tied to its functional purpose. Dealing with the standardization of manufacturing objects such as screws and shipping containers, ISO's legitimacy has generally stemmed from technical proficiency, principles of rationality and solving collective problems (Loya & Boli, 1999). Following its foundation in 1946, ISO covers a wide range of technical fields such as manufacturing and communication technology. However, in the 1980s, ISO broadened its scope from exclusively technical standards to include standards addressing social and environmental issues (Graz, 2019; Heires, 2008). This began with the publication of standards on quality management and

assurance (ISO 9000) in 1987, followed by standards on environmental management (ISO 14000) in 1996 and social responsibility (ISO 26000) in 2010 (K. Hallström, 2008). Thus, two generations of standards emerged – the "physical standards" and the "societal standards" (Ruwet, 2011). Figure II.1 illustrates this development through the establishment of more societally oriented TCs in the 1980s.

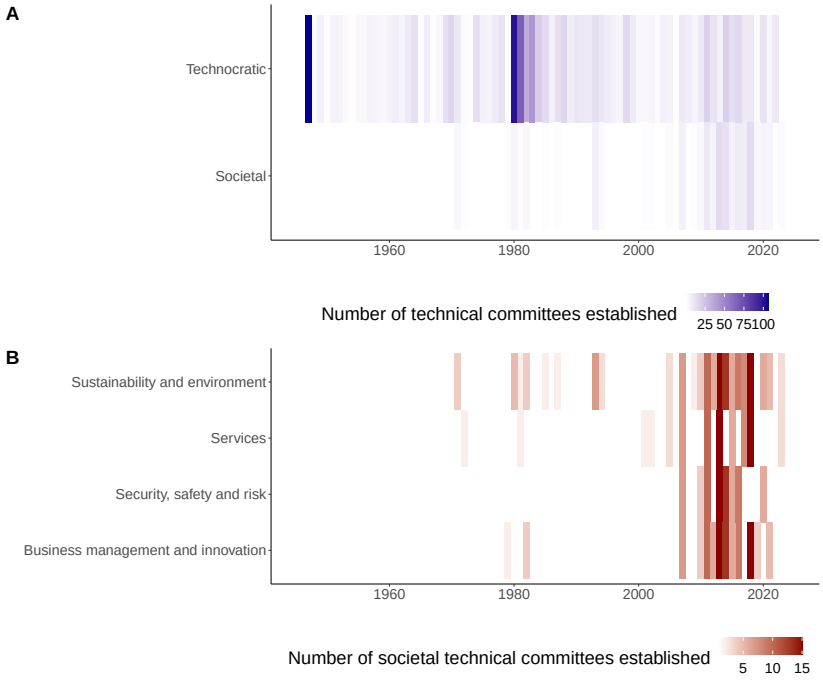

Figure II.1: Establishment of technical committees: Technical and Societal.

Based on the above discussions, ISO's legitimation strategies are expected to vary depending on whether a standard is societal or physical. This expectation finds support in other accounts, such as Bartley (2022, p. 190), who notes that internal dynamics differ between "technical standards, like the competition between Blu-ray and HD-DVD formats" and issues over "sustainability and fairness in global production networks". Furthermore, Peña (2015) argues that standards are organized within different function systems, with legitimacy depending on those systems' logics, in particular, "one normative and policy-oriented, and one knowledge-based and aimed towards innovation" (Peña, 2015, p. 67).

The legitimacy of a specific standard in a given context depends on the perception of its core stakeholders. For ISO, these stakeholders include a broad range of actors, such as small and medium-sized businesses, larger companies, multinational enterprises, non-governmental organizations, and public organizations. Among these actors, technocratic

output legitimacy has weighed heavy when evaluating both technical and societal standards, emphasizing ease of implementation and ability to provide competitiveness, efficiency and profitability (Bailey et al., 2020; Kamil et al., 2023; Urban, 2012; Van der Wiele et al., 2009).

Although this suggests a technocratic legitimation strategy for ISO, there has been pushback against this focus as ISO expanded its portfolio. The ISO 14000 series on environmental management faced criticism for lacking democratic input legitimacy, specifically for not having a representative delegation in terms of global reach and organizational diversity to negotiate the standards (Heires, 2008). Thus, when ISO expanded into the broader field of social responsibility (ISO 26000), some core stakeholders raised concerns about the standards' representativeness. For instance, ISO faced criticism from the International Labour Organization (ILO) and the UN Global Compact for attempting to regulate public issues typically governed by intergovernmental organizations (K. T. Hallström, 2010). ISO responded by implementing more democratic procedures, such as establishing fixed stakeholder categories to create a multi-stakeholder process and framing the standards as guidance documents rather than certifiable standards (Castka & Balzarova, 2008; K. T. Hallström, 2010). This approach has led to ISO being termed a "multi-stakeholder standard setter" (Hahn & Weidtmann, 2012).

II.6 Analysis

This section utilizes ISO's shift to study its legitimation strategies, employing the two-dimensional framework from section II.3. To analyze standards broadly, I use the StanDat Database (Bjørkholt, 2025) and classify standards into either physical or societal through the Large Language Model GPT-3[7]. Following Ruwet (2011), the standards are classified according to the definitions provided in table II.2. Figure II.2 displays the share of ISO standards given the physical and societal category respectively, illustrating ISO's increased expansion into societal issues.

The measure of legitimation strategies warrants some discussion. Legitimation, being a complex concept, does not only vary according to "standards of legitimation", but also other dimensions such as its intensity and mode (Schmidtke et al., 2023). Intensity is the frequency of legitimation and mode is the type of practices institutions

[7] gpt-3.5-turbo-0125 is a budget-friendly coding assistant which has shown itself to be on par with using research assistants and crowd-coders (Gilardi et al., 2023). Its training on large quantities of text gives it a versatility in a wide range of tasks (Kocoń et al., 2023). This is useful when coding technically comprehensive text, such as the abstract of standards. While the model's reliance on training data might introduce bias or errors (without uncertainty estimates), this is unlikely to be an issue here because the task does not involve bias-prone data or require precise answers. The final classification correlates with standards' sustainability goals and TC origin, enhancing its validity. Prompt and validation can be found in Appendix B.0.1.

	Definintion	**Examples (International Classification of Standards, ICS)**
Physical	Provide technical specifications, scientific formula or ICT specifications. They ensure interchangeability and solve coordination problem. Physical standards are specific to products, materials or behaviors and focus primarily on the final results.	Coding of audio, video, multimedia and hypermedia information, Road transport, Paper and board, Footwear, Salts, Telephone networks, Chemical analysis, Petroleum products in general, Cork and cork products
Societal	Address performance, quality, safety and health in manufacturing processes. They may for example address sustainable development, labour standards, corporate social responsibility, management practices or the service economy. Societal standards focus on regulating the organization or system as a whole.	IT Security, Management systems, Management of human resources, IT applications in education, Environmental economics. Sustainability, Ergonomics, Education, Other standards relating to leisure and tourism

Table II.2: Definitions and examples of physical and societal standards, based on Ruwet (2011).

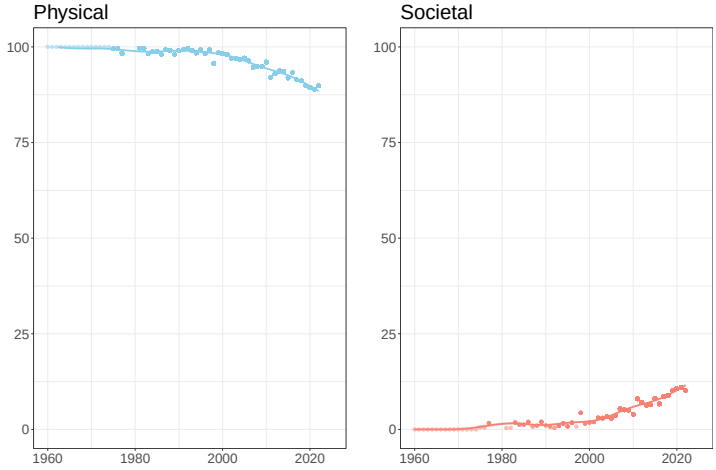

Figure II.2: Share of physical and societal standards per year.

use, such as discursive, behavioral or institutional. While this analysis does not systematically assess the impact of various legitimation modes, it includes both institutional (input legitimation) and discursive measures (output legitimation) to broadly explore the link between issue area and legitimation strategies.

Democratic input legitimation is measured as the participatory quality of standard-setting from both national member bodies (countries) and liaison organizations (i.e.

independent organizations that are included into the process). These "committee diversity" measures proxy the regional and sectorial variation of participating members in TCs. A greater diversity of actors involved in the standardization process reflects inclusiveness and mirrors a multi-stakeholder approach, where affected groups are invited into decision-making to enhance institutional accountability (de Bakker et al., 2019). Both indicators are quantified using two common measures of diversity (Boydstun et al., 2014); the Douglas Rae's method of electoral fractionalization (Rae Index) and the Shannon Diversity Index (Shannon H). I use the normalized versions of both to account for the potential of each committee to be represented from a total of five regions or ten sectors. Thus, the measure expresses to which degree TCs are dominated by representatives from one region or one sector (lower values) or sporting high diversity from various regions or sectors (higher values). Details for both measures can be found in Appendix B.0.2.

Technocratic input legitimation is measured as committee expertise. Because there are no widely agreed quantifiable measures of technocratic processes, I use multiple variables (Bertsou & Caramani, 2020). First, two variables are gathered from the World Bank: "Research and development expenditure (as % of GDP)" and "Researchers in R&D (per million people)". Second, I use five variables from WIPO: "High tech exports as % of total trade", "University-industry R&D collaboration", "Scientific and technical articles/bn PPP$ GDP", "Gross domestic expenditure on research and development (GERD) performed by business, % GDP" and "Percentage knowledge-intensive employment". These measures proxy countries' expertise, particularly industry expertise, emphasizing their ability to send competent representatives to TCs. The latter variables only have data from 2013, while the former have data for the complete time series, but the number of country-years covered are not complete for either dataset. Details and discussions of these measures can be found in Appendix B.0.3.

In the input legitimation models, one unit is a TC, and the independent variable measures committee diversity or expertise respectively. The dependent variable is the number of societal or physical standards developed within the committee in the given year.

For the output legitimation models, I measure the ISO's justification of their standards to a wider audience in ISO's news feed using two methods; dictionaries and coding of legitimation statements.

First, for the dictionary methods, measure democratic and technocratic rhetoric. There are two democratic dictionaries; one compiled from speeches in the United Nations General Assembly (UNGA) between 1990 and 2000 (Baturo et al., 2017), and one Corporate Social Responsibility (CSR) dictionary made by Pencle and Mălăescu (2016). The CSR dictionary is composed of four different dimensions, each relating to various expressions of democratic legitimation, namely labor, human rights, environment and community. Details for these dictionaries are available in Appendix B.0.4.1 and B.0.4.2.

I compile two dictionaries of technocratic legitimation; one based on abstracts from research papers and one based on abstracts from patents, with relevant texts filtered out based on keyword search for technocratic legitimation words. Details of these dictionaries can be found in Appendix B.0.4.3. The most frequent words were selected for the technocratic and UNGA Debates dictionaries to match the size of the existing CSR dictionary (160-250 words). Details on dictionary creation and cutoff sensitivity checks are in Appendix B.0.4.

The dictionaries are used to analyze word usage in ISO news articles. The dependent variable measures the share of democratic or technocratic words in an article, while the independent variable indicates whether a societal or physical standard was mentioned.

Second, following Schmidtke et al. (2023), I code legitimation statements by dividing news pieces into sentences and, using GPT-3, determine if a sentence is a legitimation statement, including whether it is democratic or technocratic. Here, the dependent variable measures share of sentences with democratic or technocratic legitimation statements. Details and validation are in Appendix B.0.5.

All models are OLS with fixed effects on committee and year and clustered standard errors. Because of the variables' temporal aspect, input legitimation is treated as an independent variable and output legitimation is treated as a dependent variable. While detailed explanations and tables for each analysis can be found in Appendix B.0.6, figure II.3 summarizes the results in a coefficient plot. In this figure, the coefficients are standardized to allow for better comparison between effect sizes.

The results generally meet expectations: ISO typically uses democratic legitimation strategies for societal standards and technocratic strategies for physical standards. The results also indicate that there is a trade-off in choosing legitimation strategies, as the relationships reverse when changing standard type.

First, for input legitimation, committees composed of countries with high degree of expertise produce more physical standards and less societal standards. For example, when a committee increases its number of researchers per million with eleven people, it is expected to produce one more physical standard per year and slightly reduce its production of societal standards. On the other hand, ISO is significantly more likely to organize regionally and sectorally diverse TC negotiations when producing standards on societal issues. For instance, if a committee would increase its regional diversity by half on the Shannon H index, the models predicts a production of one more societal standard per year. Because TCs produce few societal standards per default, 2 societal compared to 46 physical, these are substantial results.

Second, for output legitimation, there is a significantly higher chance of mentioning physical standards when the news employ patents' technocratic vocabulary and technocratic legitimation statements. Mentioning a physical standard is expected to increase the share of sentences being technocratic legitimation statements with 7 percent, and to reduce it similarly when mentioning a societal standard. ISO is also

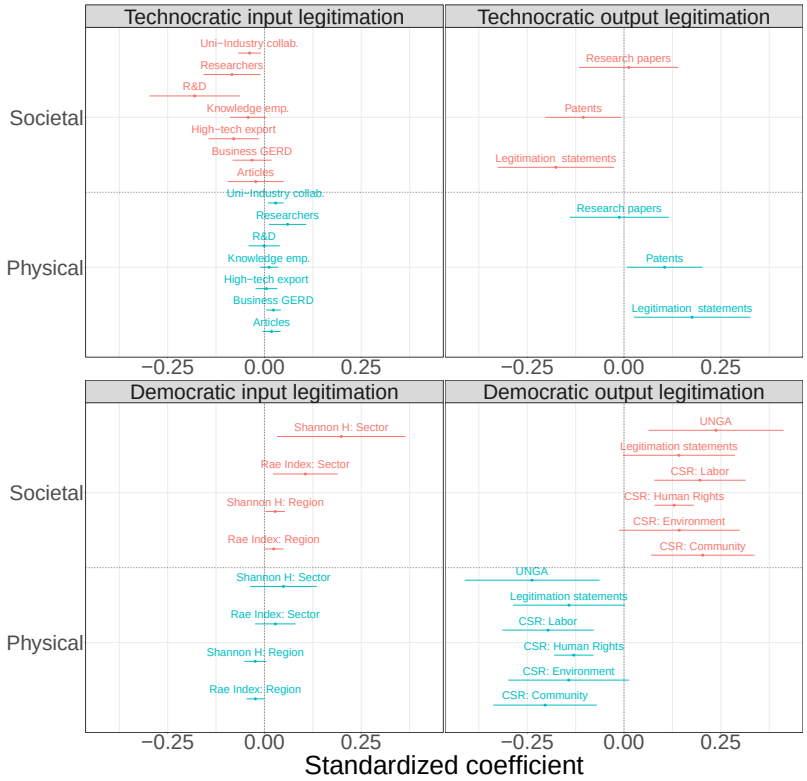

Figure II.3: Coefficient plot for the relationship between democratic input and output legitimation when producing societal standards and technocratic input and output legitimation when producing physical standards.

more likely to justify societal standards in a democratic rhetoric. The relationship is positive and robust across dictionaries. For example, using the UNGA dictionary, when ISO writes a news piece mentioning a societal standard, its use of democratic wording increases by 3 percent.

Being an observational study, this analysis cannot fully disentangle the mechanisms leading to changes in legitimation strategies. However, employing year- and committee-fixed effects helps control for some potential drivers, such institutional entrepreneurs' initiatives and stakeholder negotiations within individual TCs, or isomorphic pressures that cause all TCs to become more similar over time (Schleifer, 2019). Overall, these findings support the theory that which issue area a TPI regulates may in itself influence legitimation strategies due to the normative expectations within that issue area (Bernstein, 2011).

II.7 Conclusion

The study of how legitimacy stems from various sources and how this influences legitimation strategies has been a prominent area of research for international organizations (Dingwerth et al., 2020; Schmidtke & Lenz, 2023; Schmidtke et al., 2023; Sommerer et al., 2022). However, transnational private institutions (TPIs) have not garnered the same level of attention. TPIs represent a compelling subject for examining legitimation strategies due to the inherent tension they face between democratic and technocratic legitimacy. Scholars have furthermore observed an increase in democratic legitimation through multi-stakeholder processes among TPIs, highlighting the importance investigating these patterns (Boström & Tamm Hallström, 2013; de Bakker et al., 2019; Mena & Palazzo, 2012; Moog et al., 2015; Schleifer, 2019). This paper applies frameworks developed for international organizations (Tallberg & Zürn, 2019) to test theoretical expectations about the factors driving changes in legitimation strategies for TPIs (Bernstein, 2011), using the International Organization for Standardization (ISO) as a quantitative case study.

I propose that the framework of Tallberg and Zürn (2019), which includes a two-dimensional approach integrating both technocratic and democratic legitimation along with input and output legitimation, is a useful tool for examining the legitimation strategies of TPIs, as it facilitates more comprehensive studies of the various factors driving changes in legitimation strategies than the traditional input-output model (Scharpf, 1999). For example, the shifting regulatory scope towards societal issues such as human rights, labor protection, and environmental considerations (Bartley, 2007) may lead to more democratic legitimation strategies at both input and output stages (Bernstein, 2011). Using ISO's expansion into societal standards as a case study, the findings support this theory. For traditional physical standards, ISO uses technocratic legitimation strategies, whereas for societal standards, it employs democratic legitimation. These patterns occur in both the input and output phases of the standardization process. Consequently, this study argues that a two-dimensional framework is effective for analyzing legitimation strategies among TPIs and that issue area may significantly influence their choice between technocratic or democratic legitimation.

Using novel data on ISO standards, this study extends research on ISO and finds that patterns seen in major standard series such as ISO 14001 (Environmental Management) and ISO 26000 (Social Responsibility) also apply to less prominent societal standards. Yet, using ISO as a case study for TPIs has some advantages and some limitations. First, this study offers indicative evidence on how issue area may influence shifts in legitimation strategies by holding organization constant and using a fixed effects model, for which committee characteristics and year-wise developments can be held constant. Future research is invited to study this link further among other TPIs and with other

issue and legitimation operationalizations.

Second, despite being called a typical TPI (Büthe & Mattli, 2011), the case of ISO does not automatically generalize to other TPIs. The group of TPIs is very diverse, and ISO has a particularly wide mandate. In a narrow sense, these findings may extend to other private non-market organizations, including other international standardization organizations such as the European Committee for Standardization (CEN), the International Accounting Standards Board (IASB) and the International Electrotechnical Commission (IEC) (Büthe & Mattli, 2010). However, given how previous studies indicate that many TPIs engage in regulating societal issue areas and pursue democratic legitimation strategies such as multi-stakeholder initiatives, it would be worthwhile to also analyze these patterns for a wider set of TPIs. The study of ISO proves a plausibility check that issue areas may drive choice of legitimation strategies among TPIs.

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Paper III

Geopolitics in International Standardization Negotiations: Outward Technology Diffusion and Technological Sovereignty

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Abstract

Accelerating technological development and larger ideological differences internationally has brought technological sovereignty to the forefront. How can states ensure their technological sovereignty without withdrawing from international cooperation? This paper follows up on recent suggestions to understand international standardization as a method for states to bolster their technological sovereignty vis-a-vis other states. Understanding international standardization as a method for spreading domestically advantageous technology globally, here termed outward technology diffusion, this paper explores dynamics of conflict and strategic standardization in the International Organization for Standardization (ISO). The findings indicate that standardization processes, despite often being framed as technical and apolitical, are systematically influenced by political and economic inter-state relations, and that when technologies have a high impact potential globally, states are more likely to pursue standardization production that aligns with their own domestic technology.

III.1 Introduction

Although international standards may seem like uncontroversial and straightforward technical regulations, the standardization process is frequently said to be characterized by "compromises, bitterly contested power plays, and negotiations" (Timmermans & Epstein, 2010, p. 77). From the late nineteenth century contestation between the "inch" countries and the "metric" countries (Mihm, 2022; C. N. Murphy & Yates, 2019) to the ongoing competition between the European and North American countries against China on the standardization of 5G networks (Christoph Becker & Nanni, 2024; Maxigas & ten Oever, 2023; T. N. Rühlig & Ten Brink, 2021), standards can be quite conspicuous objects. Yet, although many scholars have highlighted the geopolitical tensions present in standardization negotiations (Malkin, 2022; T. N. Rühlig, 2022; Zúñiga et al., 2024), there remains a limited understanding of how widespread these conflict truly are and the factors that fuel them.

This article addresses these questions by studying the prevalence and drivers of strategic concerns and rivalry in the standardization process at the International Organization for Standardization (ISO). The article connects standardization to geopolitical tensions by drawing on recent contributions that suggest standardization can serve as a means of achieving technological sovereignty (Blind, 2025; Edler et al., 2023; T. N. Rühlig, 2022; ten Oever, Milan, et al., 2022). That is, standardization can reduce a country's structural dependency on foreign technology. I propose that this is facilitated through a process I refer to as "outward technology diffusion", which, in contrast to the act of adopting relevant technology, refers to the act of convincing others to adopt a given technological solution. Through international standardization, states can disseminate domestically advantageous technological solutions and thereby reduce their reliance on foreign technology, bolstering technological sovereignty.

The theoretical standpoint leads to two expectations regarding the drivers of geopolitics in international standardization negotiations. First, states are expected to pursue strategic standardization, meaning making standards that align with domestic technology, when the technology in question is general-purpose, as these are found to be particularly influential when diffused (Ding, 2024b). Second, standardization negotiations are expected to produce geopolitical conflicts between states that aim to achieve technological sovereignty.

Utilizing a novel large-N dataset encompassing all standardization negotiations at ISO from 2004 to 2021, I assess these expectations and find general support for the hypotheses. This paper enriches the existing literature by clarifying a mechanism through which standardization becomes a geopolitical issue, and empirically testing the implications of this theory. The findings provide evidence that strategic considerations and geopolitical rivalry substantially impact the standardization process at ISO.

III.2 Technological sovereignty and standardization power

As technology is increasingly interwoven into the geopolitical landscape, the stakes are raised on states' technological sovereignty (Eriksson & Newlove-Eriksson, 2021; Leese & Hoijtink, 2019; March & Schieferdecker, 2023) [2]. Technological sovereignty implies an absence of one-sided structural dependency on other foreign companies when developing key technologies that affect the state's political and economic sovereignty (Edler et al., 2023). For example, when domestic manufacturers rely on big tech cloud providers such as Amazon Web Services (AWS), Microsoft Azure, Google Cloud and Alibaba Cloud to improve products and operations, technological sovereignty is potentially compromised (Staab et al., 2025). Although questions of technological sovereignty have been on the agenda for a long time (Grant, 1983), the rise of the new digital economy along with increased geopolitical instability has sparked a renewed debate (March & Schieferdecker, 2023). Many recent programs exemplify states' pursuit of technological sovereignty, such as the "Made in China 2025" strategy plan for technological leadership (Zenglein & Holzmann, 2019), Germany's National Industrial Strategy plan to promote domestic technology champions (Schneider, 2023), the European AI Act which regulates the use of artificial intelligence (Mueck et al., 2025), and the US CHIPS and Science Act which seeks to strengthen U.S. prominence within the semiconductor industry (Luo & Van Assche, 2023).

Recently, several scholars have argued that participating in international standardization can be a tool to enhance technological sovereignty (Blind, 2025; Freimuth, 2024; Malkin, 2022; T. Rühlig, 2023). Behind lies an acknowledgment that achieving technological sovereignty is a balancing act between collaboration and independence. Although technological sovereignty is sometimes linked to the isolationist strategy techno-nationalism (Luo, 2021; Lynn & Salzman, 2023), many scholars argue that this strategy can be detrimental to technological sovereignty rather than enhancing it (Blind, 2025; March & Schieferdecker, 2023). Techno-nationalism emphasizes avoiding or minimizing dependency on foreign technology by amplifying domestic innovation and production of critical technology (Kohno, 1995). However, technological objects, from mRNA vaccines to quantum computing, exist within complex innovation and produc-

[2]There are many ways technology impacts geopolitical relations. For one, technological capacity is often considered to be among states' core power resources, along with economic and military capacity (Brooks & Wohlforth, 2016; Mayer et al., 2014; Paarlberg, 2004). Through technological advancement, nations can, for instance, improve economic growth (Kennedy, 2010), strengthen military capabilities (Horowitz, 2020) and control online information flow (Carr, 2015). Second, scientific and technical knowledge in political processes steers outcomes, as it influences agenda setting, defines problems and provides advice that, although based in scientific facts, will never be purged for value judgments (Louis & Maertens, 2021; Weingart, 1999). Third, expertise can become a source of authority, as actors assert sovereign agency by framing their interests as "natural and universal rather than arbitrary and particular", thereby leading others to navigate and seek recognition within imposed categories (Sending, 2015, p. 11).

tion networks that advance at an accelerating speed, making it practically impossible to build separate technological structures domestically (J.-D. Lee et al., 2024). Thus, although one-sided structural dependency on foreign technology reduces technological sovereignty, so does withdrawing from international technology collaboration, because it can hamper productive capacity, limit learning opportunities, and reduce innovative potential. In this perspective, international collaboration is neither a complete zero sum game nor always mutually beneficial, but a question of strategic maneuvering to achieve domestic goals and steer development in a preferred direction, while also benefiting from international collaboration (Powell, 1991).

International standardization is an example of such technological collaboration. Standards are detailed technical regulations providing instructions for a wide set of products and processes, for example methods to maintain the sterility of medical devices, acceptable levels of residual pesticide in food production, and frameworks for preventing workplace injuries and illnesses (Büthe & Mattli, 2010; Graz, 2019). Although standards are voluntary and often regarded as "soft regulation" (Kerwer, 2005), they can become practically mandatory if they are incorporated into national law or if they become so widely dispersed that non-conforming actors are in practice excluded from the marketplace (Brunsson & Jocobsson, 2002; Loconto & Busch, 2010). Consequently, an international standard can significantly influence technological development.

One of the most prominent examples of how international standard-setting is used to enhance technological sovereignty is that of China. Over the past decades, China has grown to become a significant technological powerhouse. Its standardization activity is an important part of this development, as prescribed in the "China Standard 2035" strategy (Seaman, 2020), and illustrated in its increased leadership positions in international standardization organizations, participation and leadership in technical committees, and increased declaration of standard-essential patents (T. Rühlig, 2023). The development has sparked responses from the rest of the world, particularly from the EU and the United States (T. N. Rühlig & Ten Brink, 2021). China wants to improve its technological sovereignty, and among the approaches used to achieve this is to increase engagement in international standardization (Kim et al., 2020).

Several scholars have theorized on the factors that link standardization participation to technological sovereignty. Malkin (2022) argues that international standard-setting is a key component of productive power[3]. Productive power, defined within Susan Strange's framework for structural power, refers to the capacity to influence or control the processes by which wealth is generated in the global economy (Strange, 1987). Firms that set technological standards establish frameworks for global value chains, which again channel profits by defining low-end and high-end tasks of production.

[3]Other key components of productive power, according to Malkin (2022), are centrality in global value chains, market power, and asset ownership.

By setting standards that align with their own technological strengths or economic interests, dominant states can gain competitive advantages, shape global markets, and maintain control over technological and industrial developments, enhancing their technological sovereignty (Drezner, 2019; Giacomello et al., 2021; Kaltofen et al., 2019). Perry and Nölke (2006) provide an example of how standards can structure social relations. They argue that accounting standards define efficiency from, specifically, a financial standpoint, by assigning labels to assets that emphasize certain aspects of the capital-labor relationship while obscuring others, thus effectively defining "the rules of the game".

Further exploring the power of standards, T. Rühlig (2023) argues that standardization power is a multi-dimensional concept. It entails an economic dimension, for example costs of redesigning products to fit with new standards; a legal dimension, such as the World Trade Organization (WTO) agreement which mandates use of international standards if a domestic standard prevents trade; a political dimension, for example how standards can affect domestic security in digital infrastructure; and an ideational dimension, including standards' potential to normalize ethical values through technological decisions. While T. Rühlig (2023, p. 55) argues that "[t]he ability to shape technical standardization [...] is a source of power in itself", Blind (2025) argues that standards have an instrumental effect on technological sovereignty. They can safeguard technological sovereignty by, for instance, strengthening R&D performance, improving trade options and facilitating innovation.

In the following section, I synthesize these observations, arguing that standardization is an important tool to achieve technological sovereignty because it is a method to spread domestic technology to other nations, what I term outward technology diffusion. By participating in international standard-setting, actors can draw on international collaborative fora while still steering technological developments in preferred directions. Thus, standardization is a way to attain outward technology diffusion, which again becomes a means to achieve technological sovereignty. Relying on this conceptualization leads not only to the expectation that standardization negotiations are largely driven by strategic concerns and rivalry, but allows me to derive some hypotheses on how these drivers manifest. The next section elaborates on these expectations before I empirically test them.

III.3 Standardization and outward technology diffusion

Diffusion capacity is a fundamental component of technological sovereignty. Technological sovereignty is a question of technological capabilities in relation to other economies, and technological capabilities are often categorized into innovation capacity and diffusion capacity (Perilla Jiménez, 2020). Where innovation capacity refers to a state's ability to introduce novel technology, diffusion capacity is the ability to spread

an innovation through a system or population (Ding, 2024a, p. 179). Some scholars argue that diffusion capacity is as crucial a metric as innovation capacity (Ding, 2024a; Romer, 1993), and some studies even indicate that diffusion metrics may be superior to innovation metrics in explaining productivity and economic growth (Alexopoulos, 2011; Maloney & Valencia Caicedo, 2017). After all, an invention, however brilliant, has little consequence if it is never spread to others.

Standardization is precisely a means of making solutions widespread, by segmenting one technological solution to ensure compatibility, predictability and efficiency in the market. Hence, diffusion is a central aspect of standardization. Indeed, Blind (2019) has argued that standardization data has underutilized potential as a science and technology metric. I conceptualize standardization as a method to achieve technology diffusion, but this conceptualization comes with a twist. Typically, technology diffusion is understood as the ability of a country or firm to adopt new innovations. International standards, by contrast, establish guidelines to boost *global* adoption rates of new technology. This approach involves agreeing on unified technological solutions to be adopted and used by all stakeholders, shifting the focus from whether a specific actor adopts a technology to whether *other actors* embrace the specified technology. I refer to this particular form of diffusion as "outward technology diffusion".

By engaging in outward technology diffusion, states can spread their preferred technologies globally, thereby reducing structural dependencies on foreign technology and enhancing technological sovereignty. As a result, states have much to gain from both participating in international standardization and promoting standards that align with their national interests and values. Standards not only dictate current manufacturing practices but also shape the commercialization of future technological innovations (Malkin, 2022). As Heires (2008, p. 360) observes, "[n]ot every standard [...] is equally relevant for all members, but most standards do have a broad impact and alter the course of future technological development."

A perspective that emphasizes the ability of outward technology diffusion to enhance technological sovereignty reveals how standardization processes can spark conflict and rivalry. Standardization is sometimes perceived as a simple coordination game of finding the optimal technological solution to rectify market failures (Loya & Boli, 1999). However, more often than not, there is no such universally optimal solution. Although the negotiation of standards can sometimes come down to simple coordination games when all actors are indifferent between choices or consider one choice clearly superior, Büthe and Mattli (2010) note that because coordination usually entails distributional conflicts, many standardization negotiations will have several outcomes that are "Pareto-improving". Pareto-improving outcomes are "preferable to the status quo for some and at least equivalent to the status quo for all actors – but these outcomes differ in how much each actor benefits" (Krasner, 1991, p. 447). This opens the room for conflict regarding the "best solution", because "best" differs

between actors. For example, Mihm (2022) argues that the United States' historical rejection of the metric system was not only due to the very high conversion costs entailed in shifting standards, but also because American engineers and professionals objectively deemed the inch superior to the metric system. Political factors can also guide judgments. In the late nineteenth century, Britain's dominance in radio networks created a monopoly over radio transmissions, establishing the global standard and leaving Germany vulnerable to monitoring and communication disruptions, and thus to pursue emerging markets to develop its own standards (Markus Brunnermeier & James, 2018). On a more ideological basis, Maxigas and ten Oever (2023) argues that the U.S.-led internet conveyed a vision of unrestricted openness for information exchange, a global connected world. Conversely, the GSM protocol standards for mobile phones, initiated by Western European countries, encapsulated ideas of citizenship, as the technology was actively bound to state boundaries. Meanwhile, China's proposals for 5G standards embody a more segmented understanding of users, emphasizing "ontological divisions between entities based on the roles and needs attributed to civil society, the state, and capital" (p. 282). In short, economic, political, and ideological factors can each shape distinct perceptions of what constitutes the "best" solution to a global technological coordination problem, thereby creating opportunities for conflict.

III.4 Standardization negotiations in the International Organization for Standardization

The empirical focus of this paper is on the International Organization for Standardization (ISO), one of the oldest and most active standardization organizations on the international arena (Heires, 2008). Focusing on ISO restricts the analysis to committee-based standardization, acknowledging that standards are created through a variety of additional modes such as markets or government (Kerwer, 2005). International standardization that occurs through market mechanisms may be less sensitive to geopolitical rivalry and strategy, as this mode does not rely on negotiations.

As described above, standards are in principle voluntary, so when ISO sets a standard, it does not automatically translate into diffusion (Botzem & Dobusch, 2012). Diffusion becomes a question of whether adopting a standard is worthwhile, for example because it improves quality, reduces costs or lowers market uncertainty. Certification data suggest generally high adoption rates for ISO standards (Bjørkholt, 2025; Boiral et al., 2018; Sampaio et al., 2009), and studies into the adoption of management series such as ISO 14001 and ISO 9001 find that initial adoptions tend to spur further adoptions (Corbett & Kirsch, 2001; Vastag, 2004). Furthermore, standards can become "quasi-obligatory rules" (Botzem & Dobusch, 2012, p. 752) through, for instance, corporations that require suppliers to adhere to specific standards (Guler et al., 2002),

institutions that implement standards into binding rules, or standards that are so widespread that not complying makes it impossible to sell or buy in the given market (Brunsson et al., 2012). Thus, standards are not only produced with the purpose of spreading to various actors, but the diffusion of a standard may also accelerate with its initial adoption rates. Standardization at ISO thus becomes an efficient mechanism for outward technology diffusion.

As of the current date, ISO boasts membership from 172 countries, each displaying varying levels of engagement, activity, and influence contingent upon their membership status and level of participation (Alshadafan, 2020). However, it is important to acknowledge that states are in fact not themselves participating in the standardization negotiations. Standard-setting is a form of private or hybrid authority, where negotiations are held between representatives from multiple sectors such as industry, non-governmental organizations (NGOs), government, consumer groups, and research (Graz, 2019; Hallström, 2010). These representatives are, through their organization, engaged in international standardization through their "most representative" national standardization body, such as Deutsches Institut für Normung (DIN), the Standardization Administration of China (SAC) or the American National Standards Institute (ANSI). The standardization negotiations are conducted within technical committees (TCs). While each country is represented by a single national member body, they may send multiple representatives to participate in these TCs (Heires, 2008).

An important question is whether actors engaged in standardization behave in line with the state's interest in maintaining technological sovereignty. This would entail focusing on making standards that facilitate, perhaps even prioritize, domestic technology. Such a perspective differs from ISO's emphasis on the importance of consensus during the negotiation of standards, in which representatives within TCs are expected to engage in discussions in a rational, problem-oriented, and scientific manner. However, private actors are not independent from their national context. They are "almost always [...] collective actors relying on a prior principal in their owners, funders, or members." (Mattli & Büthe, 2005, p. 418). Zúñiga et al. (2024) has observed that major players in the international standardization scene, including the United States, Europe and China, while having different institutional settings for standardization processes, all converge towards a greater role for the government.

When studying the motives of domestic standardization participation among German manufacturing companies in the electrical engineering and machinery industry, Blind and Mangelsdorf (2016, p. 20) found that the most important objective was to "define technical specifications in standards documents in order to prevent mandatory regulations", followed by "to ensure that company-specific interests are included in standards documents". This was more important than gaining access to markets or finding technical solutions, and supports the notion that these private actors promote

technological sovereignty. Likewise, Blind (2002) found that the companies participating most in standardization are within patent-intensive and export-intensive branches, which are also the most exposed to reduced technological sovereignty if a standard is passed without accounting for their preferred technology.

Thus, there is good reason to believe that the production of standards is moved not only by technical considerations, but also by economic interests and power struggles (Brunsson et al., 2012; Büthe & Mattli, 2011; Graz, 2019). There were, for example, several controversies when ISO members determined the next global standard for wireless network encryption in 2006, and the options stood between the Chinese WAPI solution and the solution provided by the US-based standard setting organization Institute of Electrical and Electronics Engineers (IEEE). Despite intense lobbying from both sides, several countries expressed concerns about transparency and interoperability of the WAPI and favored the IEEE's solution. Thus, following a vote, IEEE's solution became the official international standard on wireless network security, which meant that China could not enforce foreign actors' use of WAPI domestically (Cheng, 2023; Gao, 2008; H. Lee & Oh, 2006). Werle (2001, p. 403) notes that most participants in standardization recall such conflicts, and that these conflicts most often happened within TCs during the negotiation process. Schmidt and Werle (1993) point out that committees, like courts, do not prevent conflicts, but channel them. Furthermore, it is clear that engagement in standard negotiation processes remains highly desirable for many countries (Hahn & Weidtmann, 2016). C. Murphy and Yates (2011) have observed that over the past century, the most significant conflicts in standard-setting have centered on changes regarding who is permitted to participate in the process and the criteria for achieving consensus.

III.5 Hypotheses and measurements

In the previous sections, I outlined why standardization processes may be susceptible to conflict. When viewed as a tool for facilitating outward technology diffusion, one can see how standardization can bolster technological sovereignty. By establishing a technology as the standard, a dependency is created *for others* on that particular technology. Thus, because states strive to promote technologies that benefit their domestic industries, these standardization processes can become contentious.

To assess these propositions, I derive two expectations addressing the factors that drive, respectively, strategic behavior and rivalry in standardization negotiations. This section motivates these expectations and outlines the various measures used to proxy strategic interest and rivalry respectively. All measures are based on data from the StanDat database (Bjørkholt, 2025).

Strategy

The first expectation pertains to strategic standardization. If standardization is indeed a method of obtaining technological sovereignty, we should observe states pursuing strategic standardization, meaning seeking to standardize technology that is of particular importance to their domestic reality. Furthermore, we would expect to see strategic standardization as a means to enhance outward technology diffusion.

To assess this, I analyze the degree of strategic standardization when the technology is general-purpose. Ding (2024b) argues that general-purpose technologies (GPTs), such as steam engines or artificial intelligence, are particularly suited to produce shifts in structural power, due to their broad applicability across sectors and industries. Because GPTs are particularly suited to facilitate the diffusion of technology due to their widespread usage, the GPT-focused perspective recognizes the importance of technology diffusion in maintaining technological sovereignty. I therefore expect strategic standardization to be particularly prevalent when the technology in question is a GPT. This generates the first hypothesis:

H1: General-purpose technologies are more likely to become objects of strategic standardization.

I operationalize strategic standardization as the compatibility of international standards to domestically advantageous technology. Using patented technology to proxy the latter, I assume that countries want to lobby their own patented technology to become international standards. Compatibility is measured as the similarity between patents issued by the country in t-1 and international standards produced in t. Specifically, similarity is measured by finding the cosine text similarity between international standard abstracts and domestic patent abstracts. PatentsView is used for data on patents (Toole et al., 2021).

The rationale behind using textual similarity measures as a proxy for domestic relevance of international standards draws on observations of declared standard-essential patents (SEPs). SEPs are patents that claim an invention that must be used to comply with a technical standard, so that any product or service that intends to adhere to these standards must use the technologies covered by SEPs. These types of patents have been referred to as more valuable, as they are cited more frequently and for a longer period than non-SEP patents (Rysman & Simcoe, 2008). Moreover, they contribute more to firm profits and market value than comparable patents (Hussinger & Schwiebacher, 2015; Pohlmann et al., 2016). This indicates that correspondence between domestic patents and international standards is advantageous.

Recently, scholars have argued that SEP data may underestimate the number of SEPs in the economy, as firms might avoid disclosure due to restrictive rules, lack of awareness, or because the patents are held by non-contributors to the standardization

process (Baron & Pohlmann, 2018). Thus, a new methodology was proposed to measure the actual number of SEPs in an economy by matching standards to patents based on semantic similarity, i.e. cosine similarity (Brachtendorf et al., 2023). An example of the estimation method is shown in figure III.1, and this is the method I use to measure the domestic relevance of an international standard.

Figure III.2 shows trends for the dependent variable for selected countries. The the similarity between patents issued in one year and international standards published the following year is higher in industrialized countries relative to the BRICS countries. The data support the observation that China is increasing its standardization power (T. Rühlig, 2023). India has also had a slight increase in its patent-standard similarity, but it is more varied than for China. Other than that, the trend is not visible for the other BRICS. Meanwhile, interestingly, the graph portrays a slight decline in the patent-standard similarity for the United States.

Patent publication:
US 6,662,155 B2 (2003-12-09)

"The background noise can be classified as stationary or non-stationary based on the spectral distances ΔD_i from each of the spectral parameter (LSF or ISF) vectors $f(i)$ to the other spectral parameter vectors $f(j)$, $i = 0,\ldots,l_{dtx} - 1, j = 0,\ldots,l_{dtx} - 1, i \neq j$ within the CN averaging period (l_{dtx})."

Standard specification:
ETSI TS 126 192 V8.0.0 (2009-01)

"The encoder first determines how stationary background noise is. Dithering is employed for non-stationary background noise. The information about whether to use dithering or not is transmitted to the decode using a binary information (CN_{dith}-flag).
The binary value for the CN_{dith}-flag is found by using the spectral distance ΔS_i of the spectral parameter vector $f(i)$ to the spectral parameter vector $f(j)$ of all the other frames $j = 0,\ldots,l_{dtx} - 1, j \neq i$ within the CN averaging period (l_{dtx})."

Figure III.1: Textual similarity between patents and standards. The quoted text of the patent publication is part of the patent description. Figure taken from Brachtendorf et al. (2023).

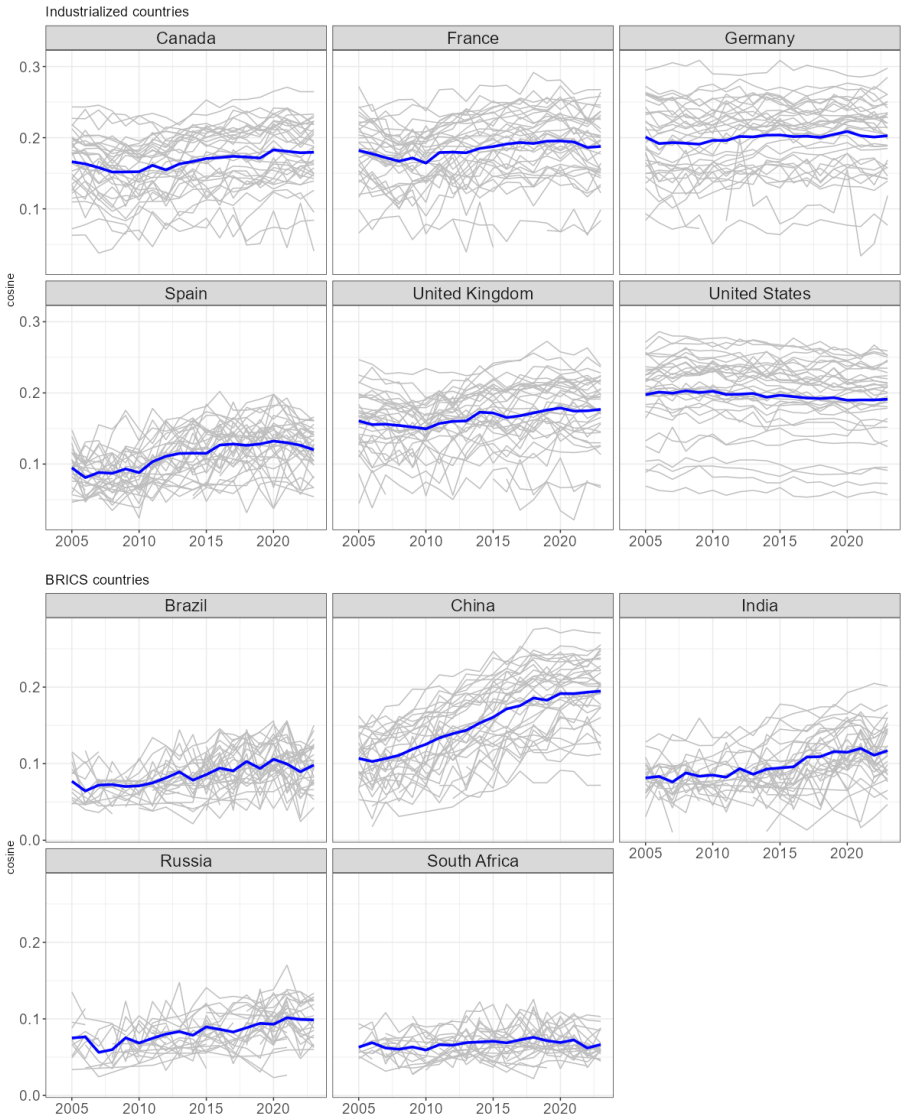

Figure III.2: Textual similarity between patents and standards for selected countries over time.

The independent variable is whether the technology in question is a general-purpose technology (GPTs). GPTs, however, can be difficult to categorize. Heikkilä et al. (2023) propose three characteristics of GPTs: pervasiveness, improvement and innovation spawning, noting that these characteristics are necessary but not sufficient to constitute objective and clearly defined rules for classifying technologies as GPT. Similarly, Bekar

et al. (2018) emphasize that GPTs evolve over time.

Acknowledging these ambiguities, the analysis employs different measures of GPTs. The first draws on how "GPT-ness" is measured in Hötte et al. (2024). These scholars use patent data to measure three dimensions of GPT: growth, generality and complementary. I draw on these and measure each dimension as shown below. These measures are then standardized and added to an index. For a graph of the independent variable, see Appendix figure C.1.

- Growth as increase or decrease in patents within a specific technology for each year.
- Generality as the number of citations within a given technology divided by all citations per year.
- Complementarity as the number of subfields that patents within a given technology point to, divided by the total number of patents per year.

As a second measure, I code four variables composed of the technologies that scholars frequently list when working with GPTs (e.g. Bresnahan (2010) Basu and Fernald (2007), Youtie et al. (2008)). The most restrictive variable includes the technology fields electricity, telecommunication, energy and ICT. The second category includes infrastructural technology such as railway and road engineering. The third category includes a set of other categories that may be viewed as GPT given their broad applicability within several sectors. As a fourth check, the last category includes technologies that are often seen as specialized.

Table III.1 shows the coding scheme. The unit is country-year-technology. I employ two-way fixed effects models on country and year with standard errors clustered by country, year and technology.

Table III.1: Classification of technologies: General-purpose or specialized.

Classification	**Technology**
General-Purpose Technology 1	Electrical engineering, Electronics, Telecommunications, Information technology, Energy
General-Purpose Technology 2	Electrical engineering, Electronics, Telecommunications, Information technology, Energy, Railway engineering, Road vehicle engineering
General-Purpose Technology 3	Electrical engineering, Electronics, Telecommunications, Information technology, Energy, Railway engineering, Road vehicle engineering, Health care technology, Mechanical engineering, Mechanical systems, Image technology, Materials handling equipment, Construction materials
Specialized Technology	Environmental/Health protection, Metrology and measurement, Fluid systems, Precision mechanics, Packaging, Textile and leather technology, Clothing industry, Chemical technology, Mining and minerals, Metallurgy, Aircraft and space vehicle engineering, Shipbuilding and marine structures, Rubber and plastic industries, Paint and color industries, Civil engineering, Military engineering, Entertainment and sports

Rivalry

The second expectation concerns the drivers of conflict and rivalry in standardization processes. Given the hypothesized strategic nature of standardization, standardization should not just be influenced by technical concerns, but also economic and political factors.

Yet, there is no uniform theory regarding which economic and political drivers influence rivalry internationally. Scholars of the realist tradition tend to emphasize security concerns and military power, while those from the liberal tradition tend to view ideological differences as a main driver (Gadi Heimann & Zangl, 2025). Mazarr et al. (2021) list several different conditions that underlie the stability or rivalry of great powers, including military offense-defense balance, communication channels, existence of a common enemy, contestation over resources and personal relationships.

By understanding standardization as a method to diffuse technology, I derive more concrete expectations regarding dimensions of conflict. Political and economic institutions have been found to play an important role with regards to technology diffusion (Assiotis et al., 2015). Economic conditions include factors such as trade (Comin & Hobijn, 2010) and wage levels (Knez, 2023). Other studies support the notion that political institutions matter for technology diffusion (Cervellati et al., 2018; Comin & Hobijn, 2004; Okada & Samreth, 2024). For example, studying the diffusion of the internet, Milner (2006) found that this technology was adopted at a faster rate in democracies. For autocracies, where the internet can pose a threat in terms of information sharing and potential for collective action, policies that obstructed or restricted access to the internet slowed its spread. Knutsen (2015) found similar tendencies to restrict information flow in autocracies compared to democracies. This is not to say that states can perfectly predict the highly variable outcomes of technology diffusion (Drezner, 2019), but rather that, when faced with the prospect of losing technological sovereignty, states may attempt to hinder the outward diffusion of new technology by stalling the standardization negotiation process.

Acemoglu and Robinson (2000) argue that one way in which technology diffusion can be hindered is by blocking and stalling the implementation of innovations. Indeed, the duration of negotiations has been found to be a solid proxy for conflict in other studies. Simonelli (2011) has found that political concerns such as whether negotiations of international agreements took place during the Cold War and whether the agreement requires deeper levels of cooperation have an impact on negotiation duration. Further highlighting the political aspect of negotiation duration, Ye (2024) found that governments are less likely to sign trade agreements in election years, increasing the time it takes for an agreement to settle. For the purpose of standardization, Simcoe (2006) observed that interests derived by intellectual properties lead to delays in committee-based standardization, which again slowed the diffusion of standards.

This leads to the following hypotheses:

H2: Greater economic distance/closeness between states engaged in standardization leads to slower/faster standardization negotiations.

H3: Greater political distance/closeness between states engaged in standardization leads to slower/faster standardization negotiations.

To address these patterns of rivalry, I assess whether the efficiency of standardization negotiations are influenced by political and economic relations in the respective committees. The independent variables assess political and economic distance between states engaged in the standardization process. All data is gathered at dyad-level between countries, but aggregated up to committee-level by either taking the average or share of the number of instances. As such, the variables do not measure independent dyadic relations, but an overall relational dynamic within the committee.

The economic dimension of conflict is measured as (1) the average intra-committee share of bilateral trade and (2) the average intra-committee share of bilateral tariffs from the Comtrade database, (3) the TC share of preferential trade agreements (PTAs) from the DEEPI database (Dür et al., 2014), and (4) following the Gravity model, the TC average distance between capitals (Conte et al., 2022). The political factors are inspired by Clark (2021), who uses the variables (1) UN voting (ideal point distance) from Bailey et al. (2017), (2) alliance ties from Leeds et al. (2002), and (3) strategic rivals from Dreyer and Thompson (2011), to measure geopolitical closeness. I add a fourth and fifth variable (4), the average number of joint mentions in UN General Assembly speeches, and (5) average regime distance, which is the average difference between countries' democracy level measured from the V-Dem database's polyarchy score (Coppedge et al., 2024), all of them aggregated up to committee-level. Details on each measurement can be found in Appendix C.0.2.

The dependent variable, committee productivity, is based on the negotiation process in TCs and measures the efficiency of producing standards. Committee productivity is measured as a standard's number of pages produced per day of its negotiation process. By dividing the number of pages by negotiation time, I take into account that some standards are longer than others[4]. Negotiation time is measured from the date when a new project is approved (10.99) to the date when the international standard is registered to be published (60.00), as illustrated in figure III.3.

The data has a highly nested structure, with standards nested within committees. Intraclass correlation shows that around 37 percent of the variation in standard productivity is determined by its TC. For the first analysis, focusing on committee productivity, I therefore employ a multilevel model with standard errors clustered by committee and year-fixed effects. The model contains random intercept and random

[4]In fact, 401 standards in the dataset are but one page long, while the longest standard comprises 5656 pages

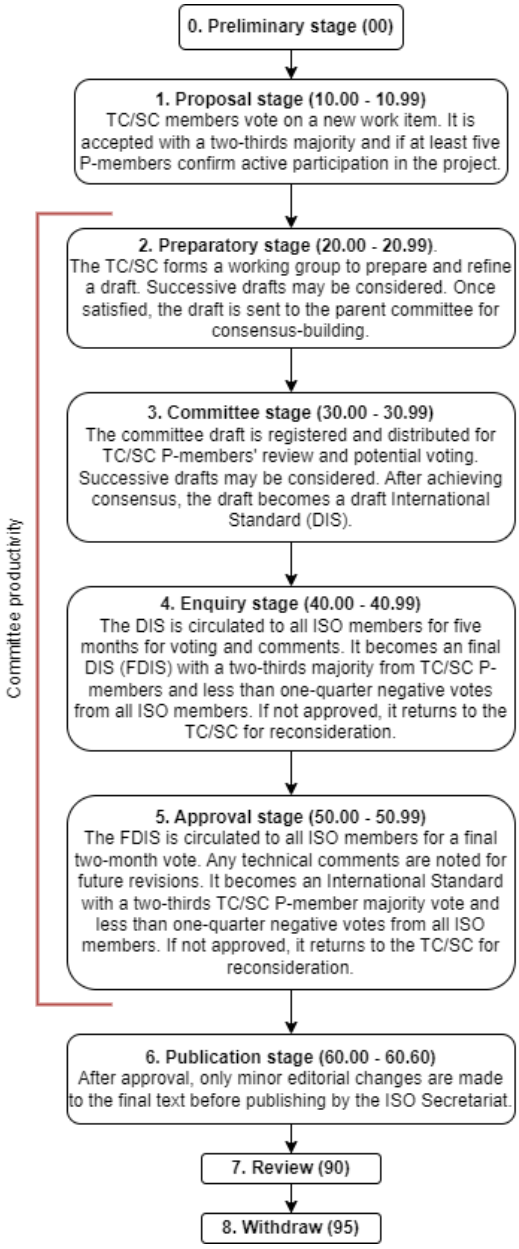

Figure III.3: Stages of the development of international standards.

effects on each committee, assuming that factors such as the leader competence, subject of the TC, historical customs, and so on, will influence both the starting-point and the degree to which productivity is affected by various economic, political and scientific concerns.

The technical complexity of the standard is an important control variable, since standards that require more detailed knowledge will be slower to develop. I measure complexity mainly by the Flesch reading ease score of the abstract, but also control for the ICS category and the edition of the standard. The productivity variable is logged to amend skewedness and as per usual with multilevel models, all continuous variables are standardized. Details can be found in Appendix C.0.2.

III.6 Analysis

Strategy

The first question asks whether countries would be more inclined to match standards to their own patents when standardizing GPTs. Table III.2 shows the results of the regressions relating to H1. The coefficients are largely in accordance with expectations. For GPTs, the similarity between domestic patents and international standards is generally higher. For example, when a technology falls within one of the categories *electrical engineering*, *electronics*, *telecommunications*, *energy* or *information technology*, estimated similarity between the abstract in domestic patents in t-1 and international standards increases by 0.009. An increase in the GPT index by one unit predicts an increased similarity of 0.006 points. As the similarity variable ranges from 0.12 to 0.3, this is a small but nevertheless substantial effect.

The findings indicate that countries engage in strategic standardization, that is, being more focused on producing standards that fit to domestic technology, when the technology in question is assumed to have wide-ranging impact. The coefficients for the "classic" classification of technologies into GPT and GPT index being positive and largely significant points to a consistent relationship between GPTs and strategic standardization. The reverse, specialized technology, is negative, but not significantly different from zero. This may indicate that countries engage in strategic standardization for several types of technology, preferring to produce standards that are similar to their own domestic technology in general. However, the fact that similarity is greater for GPTs indicates that they are particularly concerned with strategic standardization when it comes to strategically important technology.

Table III.2: GPT vs. Specialized technology and standard-patent similarity

	Cosine similarity between patents in t-1 and standards in t						
	Index of GPT	GPT 1	GPT 2	GPT 3	Specialized tech.	Index of GPT + control	GPT 3 + control
GPT index	0.006**					0.005**	
	(0.002)					(0.002)	
GPT class.		0.009+	0.010**	0.021**	−0.012		0.017*
		(0.005)	(0.003)	(0.006)	(0.007)		(0.006)
Patents per res.						0.306+	0.331+
						(0.149)	(0.160)
Democracy (poly.)						−0.031+	−0.016
						(0.015)	(0.016)
GPD growth						0.000	0.000
						(0.000)	(0.000)
Sci. & tech. journal articles						0.000+	0.000+
						(0.000)	(0.000)
Tech. in R&D (per mil)						0.000*	0.000*
						(0.000)	(0.000)
Urban population						0.000+	0.000+
						(0.000)	(0.000)
Num.Obs.	20 835	22 256	22 256	22 256	22 256	4751	4751
R2	0.592	0.572	0.573	0.597	0.579	0.626	0.631
R2 Adj.	0.589	0.569	0.571	0.595	0.576	0.621	0.626
RMSE	0.04	0.04	0.04	0.04	0.04	0.04	0.04

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Fixed effects by country and year. Standard errors clustered by country, year and technology.

Rivalry

Turning to the question of whether standardization processes are driven by economic and political rivalry, figure III.4 displays the results relating to H2 and H3. Because of the data coverage of independent variables, time series varies across the models. See Appendix table C.4 for complete model.

Overall, the results are in line with the hypotheses, although some of them are short of significance. Regarding the economic dimension, TCs composed of a relatively high number of countries with high bilateral tariffs are less productive when it comes to creating standards. Specifically, a one-unit increase in average bilateral tariffs inside the TC is associated with approximately an 8.8 decrease in the number of pages produced per day. The relationship is reversed for TCs where countries have a relatively high number of preferential trade agreements (PTAs). Here, a one-unit increase in share of PTAs increases the number of pages produced per day by 8.4. However, the coefficient is only significant at 10 percent level, indicating more uncertainty with regard to this link. The other coefficients are not significant, although the coefficient of average bilateral trade tends towards being negative, which is surprising given that more trade would usually indicate more closeness. However, high trade volumes can increase the stakes in the establishment of international standards, leading to more thorough and lengthy negotiations. It is probable that countries self-select into TCs based on their trading partners, especially if those partners are inclined to participate in the standard-setting process, where differing interests regarding the final outcomes may arise.

Regarding the political dimension, Figure III.4 shows that when a TC is composed of countries that are also part of the same defensive alliances, committee productivity increases. In particular, a one-unit increase in share of defensive alliances increases page production per day with 15. Conversely, the results indicate that a TC consisting of a high share of strategic rivals is slower at producing standards, reducing the number of pages produced per day by 5. For TCs where the countries tend to refer to each other in speeches made at the UN General Assembly, there is an estimated reduction of 3 pages per day for every unit increase. However, these two coefficients are only significant at 10 percent level. Interestingly, the coefficient of the UN voting distance metric is practically zero, indicating that general disagreements in matters of international importance does not tend to affect standardization productivity, but rather momentary disagreement spurred by current events. The regime distance coefficient indicates the same pattern. It is in the expected direction, but hardly significant, so that general differences in the democratic status of participating countries do not in itself tend to impact productivity.

These findings provide overall support for H2 and H3. Larger economic and political distance reduces productivity, while more closeness increases productivity. This

suggests that more conflicts arise when a committee is composed of countries that differ geopolitically, resulting in slower standardization processes. This finding supports case studies that find high conflict levels in standardization processes between great powers such as China and the United States, suggesting that these dynamics may be more general. However, the results point to general ideological differences not being sufficient to incur productivity declines, but rather strong stances such as bilateral tariffs, sharing defensive alliances or being in current disputes that results in several mentionings in the UN General Assembly. Furthermore, only two coefficients demonstrate statistical significance at the 5 percent level, suggesting that these relationships are not firmly established.

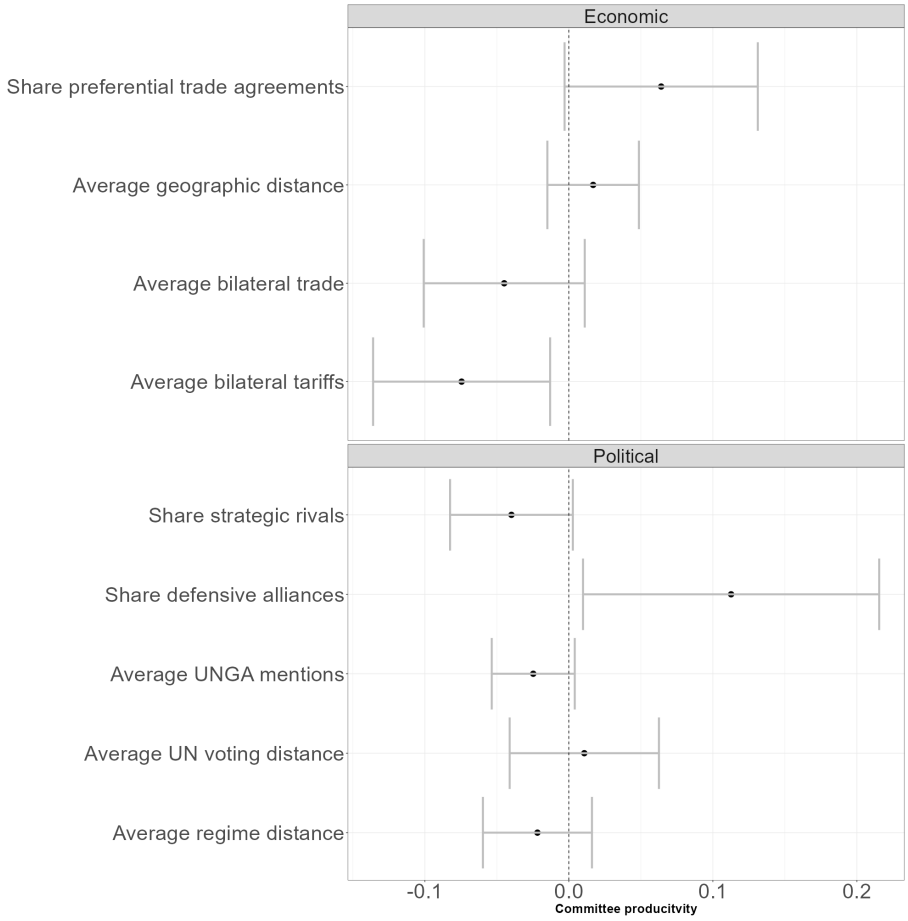

Figure III.4: Random effects model: TC composition and committee productivity.

III.7 Conclusion

In recent years, the pursuit of technological sovereignty has emerged as an important priority for leading global powers (Edler et al., 2023). However, achieving and maintaining technological sovereignty poses a complicated task. Although, intuitively, reducing reliance on foreign technology might foster self-sufficiency, scholars suggest that a stance of isolationism can actually undermine technological sovereignty (March & Schieferdecker, 2023). This prompts the question of how states effectively collaborate on technological solutions at an international level while safeguarding their technological sovereignty.

Several recent studies argue that international standardization can be used as a tool to achieve technological sovereignty (Blind, 2025; Freimuth, 2024; Malkin, 2022; T. Rühlig, 2023). I propose that this can occur through what I term "outward technology diffusion", which involves the dissemination of technology across borders. By actively participating in standardization negotiations in international forums, states can reduce their dependence on foreign technologies through formal standards, by advocating for the global adoption of technology that aligns with their domestic preferences. This dynamic introduces potential for strategic maneuvering and geopolitical competition and in the standardization process, as countries push their own technological solutions while hindering those that are incompatible with their domestic priorities.

This paper investigates this process by studying the prevalence of strategic considerations and geopolitical rivalry within standardization negotiations at the International Organization for Standardization (ISO). This rivalry has recently been showcased for particular cases, for example that between the United States and China in the standardization of information technology (Cheng, 2023; Malkin, 2022; T. Rühlig, 2023). In this study, I systematically explore these interactions across a broader sample, testing two key propositions from the literature on technology diffusion: first, whether states strategically focus their standardization efforts on general-purpose technology (GPT), and second, whether political and economic distance or closeness significantly influence the negotiation efficiency.

The analysis provides evidence supporting both hypotheses. First, the analysis finds that states are more concerned with producing international standards that fit with their domestic technology when the technology in question is a GPT. Because GPTs can have wide-ranging impacts, they are being particularly important for technology diffusion, which could incentivize a strategic pursuit of standardization in international fora. This analysis finds evidence that countries pursue strategic standardization more when the technology in question has wider impact upon spreading globally. Second, productivity is significantly lower when committees are composed of states with high mutual tariffs, and significantly higher when they are composed of countries within the same defensive alliances. The findings also indicate that other factors such as

preferential trade agreements, strategic alliances and mutual attention through the UN General Assembly have an impact on standardization negotiations. This supports the hypotheses drawn from the literature on technology diffusion, that economic and political factors play into the standardization process and that states may utilize standardization strategically, underscoring the understanding of standardization as a method to pursue outward technology diffusion and technological sovereignty.

Overall, these findings illustrate that standardization negotiations transcend purely technical discussions, being significantly driven by geopolitical considerations. This dynamic is not limited to a handful of major international powers, but represents a widespread pattern. The article emphasizes the importance of understanding standardization in a geopolitical context, suggesting that international standardization can be leveraged as a mechanism for outward technology diffusion, which, in turn, can enhance technological sovereignty for participating states.

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Appendices

Appendix A

Appendix for Presenting the StanDat Database

Codebook

StanDat Codebook

A database on international standards

Table of contents

Overview

StanDat consists of several datasets that covers several aspects of the landscape of international standards. The database is based on data from the International Standardization Organization (ISO). For more information on ISO, visit www.iso.org. For more information on the dataset, see this paper.

The database is categorized into ‘Standards’, ‘TC-membership’, ‘Historical’ and ‘Certifications’, each category with 2-3 datasets.

Category	Time series	Description	Source and method	Comments
Standards	1951 - 2023	Data on specific standards, including which technical committee that developed them, the life cycle of their production, year they were published, edition, number of pages, whether they have been withdrawn, abstract, sustainability goals and ICS code.	www.iso.org. With sublinks to every standard. Collected through webscraping using rvest.	The data has been subject to significant amounts of data cleaning.
TC-membership	2002/4 - 2023	Data on actors' membership in technical committees. There is one dataset on the countries (i.e. national member bodies) and one on the organizations in liaison.	Wayback Machine. Collected through webscraping using wayback, rvest and httr.	Because there is only a selection of snapshots of webpages in the archive, the data is incomplete. Imputation methods based on the collected data replaces for some of the missing values. The cells that have been imputed are indicated. The data has been subject to significant amounts of data cleaning.
Historical	1947 - 2015	Data on the historical development of ISO. One dataset includes membership in ISO over time, including type of membership and function of membership. One dataset shows when different technical committees were established.	Membership parsed from pdf. TC establishment scraped from iso.org and missing categories were categorized using ChatGPT.	The data has been subject to moderate amounts of data cleaning.
Certifications	1993 – 2020, but varies depending on ISO series.	Data on certifications of ISO standards. This includes data on the year of the survey, number of certificated provided by accredited certification bodies per country, industry and ISO standard series. The ISO Survey covers a selection of the ISO standard series. An overview of coverage and time series per coverage is given below.	The ISO Survey. The survey data is parsed from excel files.	From ISO: 'Every year we perform a survey of certifications to our management system standards. The survey shows the number of valid certificates to ISO management standards (such as ISO 9001 and ISO 14001) reported for each country, each year. [...] The ISO Survey is not a database. The providers of the data are the certification bodies accredited by IAF members and they participate on a voluntary basis. The level of participation fluctuates from one edition of the survey to another and can impact the survey results especially at the country level. Interpretations of the results and any conclusions on the trends should be made with these considerations in mind. The data has been subject to moderate amounts of data cleaning.

Standards

Coverage: 1951 - 2023

These datasets have standards as units, and gives information on when standards were published, the status of the standard, how large they are (in pages), which edition the standard is on, their International Classification for Standards code (ICS) (see https://www.iso.org/standards-catalogue/browse-by-ics.html), abstracts, sustainable developemnt goals that the standard fulfills, and the life cycle of the standard.

Status

Variable	Definition
stdno	Standard number
name	Name of the standard
year	Year the standard was published (standards under development are `NA`)
title	Name of TC the standard was developed within
committee	ID of the TC the standard was developed within
status	If the standard is withdrawn, deleted, developing or published
publication_date	When the standard was published (if published)
edition	The edition of the standard
pages	Number of pages of the standard
abstract	Abstract of the contents of the standard
ics_name	Name of the ICS code the standard is categorized into (canbe more than one)
ics_id	ID for the ICS code the standard is categorized into (can be more than one)
link	Link to the webpage where the information was scraped

SDGs

This dataset shows the **sustainable development goals** (SDGs) that each standard is reported to address (if any).

Variable	Definition
stdno	Standard number
name	Name of the standard
year	Year the standard was published (standards under development are `NA`)
title	Name of TC the standard was developed within

committee	ID of the TC the standard was developed within
sgd_number	Number of the sustainability goal that ISO reports the standard to contribute to (if any).
sdg_text	Name of the sustainability goal that ISO reports the standard to contribute to (if any).
link	Link to the webpage where the information was scraped

Life cycle

Process of stages for standard, as given by https://www.iso.org/stage-codes.html . The units of observation in this dataset is a life cycle stage for a given standard.

Variable	**Definition**
stdno	Standard number
name	Name of the standard
year	Year the standard was published (standards under development are `NA`)
title	Name of TC the standard was developed within
committee	ID of the TC the standard was developed within
life_stage	The stage reported in the life cycle of a given standard
life_stage_code	The code of the stage reported in the life cycle of a given standard
date	Date that the standard was at this life cycle stage
link	Link to the webpage the data was collected from

TC-membership

Coverage: 2002 - 2023

These datasets include information on the actors' membership in technical committees, i.e. that may participate in the production of standards. Standards are produced in various technical committees (TC) that are established based on demand from stakeholders, and proposed by national member bodies. To establish a technical committee, a member body sends a proposal which is then circulated among the other ISO members. At least five other member bodies have to vote in favor for the TC to be established. Those in favor take the role of P-members, and usually, the country responsible for the proposal takes the secretariat. Proposal drafts are often, in the first place, requests from other national actors.

Countries (national member bodies)

There are three member categories – full member, correspondent member and subscriber member. Only full members can become P-members (participating members) in TCs, and only P-members are able to participate actively in the technical work of the committee. Observing members are allows to follow the process but are not able to participate.

Variable	Definition
country	Country name
sdo	Name of main standardization developing organization in the country
year	Year of membership
committee	Number of TC
title	Name of TC
membership	Type of membership, either participating (P-member), observing (O-member), secretariat or twinned secretariat
impute	Whether memberships were imputed from the previous year
sector	The sector that ISO categorizes the TC into

Organizations (liaison)

Among organizations in liaison, there are four member categories, A, B, C and D, depending on how involved the organizations are in the standardization process.

Using the acronym is more reliable than using the name, as the name has been more often subject to change as webpages change.

Variable	Definition
acronym	Organization's acronym
name	Name of organization
year	Year of liaison
country	Country where the organization is located (fetched from address)
committee	Number of the committee that the organization was in liaison with
title	Name of the committee that the organization was in liaison with
type	Type of liaison for the given organization
impute	Whether the membership in given committee was imputed
sector	The sector that ISO categorizes the TC into

Historical

Coverage: 1947 - 2023

These datasets show the development of the International Standardization Organization over time in terms of members and technical committees.

Members

Shows membership in ISO over time. There are three types of membership; Participating member, Correspondent member and Subscriber member. Only P-members can participate actively in technical committees.

Variable	Definition
year	Year
country	Country
continent	Continent of country
membership_status	Which membership status the country had in the given year. U = No membership, M = membership, C = Correspondent member, S = Subscriber member.
membership_role	If there were any particular changes to the membership in the given year. with = Withdrawn, sus = Suspended, council = Council.

Technical committees

Technical committees have been established throghout ISO's history. This dataset includes some unknown missings, as some TCs have been established and then disbanded.

Variable	Definition
year	Year of establishment
title	Name of committee
committee	ID of committee
sector	The sector that ISO categorizes the TC into

Certifications

Coverage: Varying

The ISO Survey of Certifications is an annual survey of the number of valid certificates to ISO management system standards worldwide. The providers of data are the certification bodies accredited by the IAF MLA Members.

Disclaimer: The ISO Survey is not a database. The providers of the data are the certification bodies accredited by IAF members and they participate on a voluntary basis. The level of participation fluctuates from one edition of the survey to another and can impact the survey results especially at the country level. Interpretations of the results and any conclusions on the trends should be made with these considerations in mind.

Survey coverage for all datasets

Number of standard family	Name of standard family	Country coverage	Industry coverage
ISO 9001	Quality management systems	1993-2020	1998-2020
ISO 14000	Environmental management	1999-2020	1998-2020
ISO/IEC 27001	Information security management	2006-2020	2006-2020
ISO 50001	Energy management	2011-2020	2015-2020
ISO 22000	Food safety management	2007-2020	–
ISO 13485	Medical devices - Quality management systems	2004-2020	–
ISO 22301	Security and resilience	2014-2020	2014-2020
ISO/IEC 20000-1	Information technology	2015-2020	2015-2020
ISO 28000	Specification for security management systems for supply chains	2016-2020	2016-2020
ISO 39001	Road traffic safety (RTS) management systems	2016-2020	2016-2020

Country certifications

Variable	Definition
country	Country name

year	Year of survey
certificates	Number of certificates as provided by accredited certification bodies in the ISO Survey
iso	Code of ISO management standards series
iso_name	Name of ISO management standards series

Industry certifications

Variable	Definition
industry	Aggregate industry level
year	Year of survey
certificates	Number of certificates as provided by accredited certification bodies in the ISO Survey
iso	Code of ISO management standards series
iso_name	Name of ISO management standards series

Country and industry certifications

Variable	Definition
country	Country name
year	Year of survey
industry	Aggregate industry level
ISO 9001	Number of certificates within the ISO 9001 series
ISO 14001	Number of certificates within the ISO 9001 series
ISO/IEC 27001	Number of certificates within the ISO/IEC 27001 series

A.0.1 Data gathering process

You can find the complete code to produce the StanDat database on Github: https://github.com/sbjorkholt/iso-standards.

Following the construction of these datasets, I used a SQLite database to host the data, a widely popular, functional and easy-to-use database (Gaffney et al., 2022). The storing process is easily integrated into the workflow using the *RSQLite* package and the database can be hosted as a file in cloud platforms such as OneDrive or Dropbox. Moreover, storing the dataset in a SQLite database, it is relatively straight-forward to construct a fast and simple user interface with *R Shiny*. Such applications increase accessibility to the data for less technical users, and it has the advantage of storing all information pertaining to the dataset in one place, including data coverage, variable definitions and codebook. While developers are free to use any deployment method they want, deployment in *R Shiny* is made increasingly simple through RStudio's *shinyapps.io*, although costs can follow if the traffic becomes substantial.

Standards datasets

The procedure to construct the "Standards" datasets relied on webscraping. All standards produced are listed on ISO's current webpage, including the ones that are withdrawn or deleted. Thus, this scraping process utilized the current webpage of ISO only. The process involved three steps:

1. **Downloading the webpages** to a local folder. This was done by appending the strings "https://www.iso.org/standard/" and [number]. In order to catch all relevant standards, I iterated through all numbers from 1 to 150000, downloading when a webpage matching the url was found.
2. **Extracting and parsing information** from the webpages. This included finding the relevant nodes of the variables and fetching these into separate vectors, then cleaning the information. For this process, I used the R-package *rvest* and string operations, including regex, creating separate data tables for the life cycle and the general standards information.
3. **Gathering data** so that each separate datasets is can be merged into one long dataset, ensuring compatibility across all datasets.

Participation datasets

The procedure to construct the "Participation" datasets relied on webscraping. ISO got the domain "www.iso.org" in late 2001, thus, 2002 is when the time series for the participation data starts. Using the Wayback Machine API through the Wayback R-package, this scraping process is composed of three steps. Because ISO changed

their webpage four times in the period 2002 to 2023, step 1 and 2 had to be done four times with separate links and parsing processes. The four phases of ISO's webpages are:

- First version: 2002 - 2007
- Second version: 2008 - 2012
- Third version: 2013 - 2016
- Fourth version: 2017 - 2023

The three steps in making the Participation datasets were:

1. **Downloading the webpages** to a local folder. This was done by finding the url on member countries in ISO, which included a list of which technical committees they participate in. Then I used Wayback to find all snapshots of this webpage. All snapshots available were downloaded.
2. **Extracting and parsing information** from the webpage, i.e. finding relevant nodes in the webpage, extracting them, and then parsing the data to get a tidy format. This was done using the R-package *rvest* and general string operations (including regex).
3. **Cleaning the data.** This step is again composed of four steps:
    a) **General cleaning** to make all four datasets from step 1 and 2 compatible, including removing whitespace, removing special letters, ensuring that names of countries and organizations are compatible across the time series, replacing numbers/acronyms with names where relevant, etc.
    b) **Adding secondary information** from a different source of information. This was only done with the country dataset. While I have used the country-pages to construct the dataset, i.e. webpages for each member country where the technical committees they participate in are listed, another option is to use the webpages on technical committees, which lists the member countries participating. In this way, I can fill out information where a snapshot was not taken of a particular country in a particular year, by doing step 1 and 2 on the webpages for technical committees and use them to fill out missing data in the country dataset.
    c) **Imputing missing information.** Random missing values follow from the uneven snapshots of webpages taken by Wayback. A rule was followed to impute the missing values on the Participant datasets (see section A.0.2).

d) **Removing duplicates.** After imputation, some countries might have been listed as being a P-member or O-member in a technical committee while this is not the case, i.e. false positives. This can be ruled out where a country is listed as both P-member and O-member, but one is an imputation. In other cases, there are duplicates even though there are no imputations, likely a case of countries switching membership during the year. In this case, the membership in year Y+1 is chosen as the correct membership type. Lastly, a very small bunch of countries were duplicated for no obvious reason – there were imputed with O-membership as this is more common than P-membership. For countries holding the Secretariat, these tended to also be listed as P-members. I include them only as Secretariat holders.

Historical datasets

The "Historical" datasets are gathered from a PDF file, the first page shown in figure A.1. The PDF file was not machine-readable, so I ran it through Adobe to construct an excel file of the PDF file, then did some manual cleaning. In the next step, I read the excel file into R and parsed the data in order to produce a tidy format.

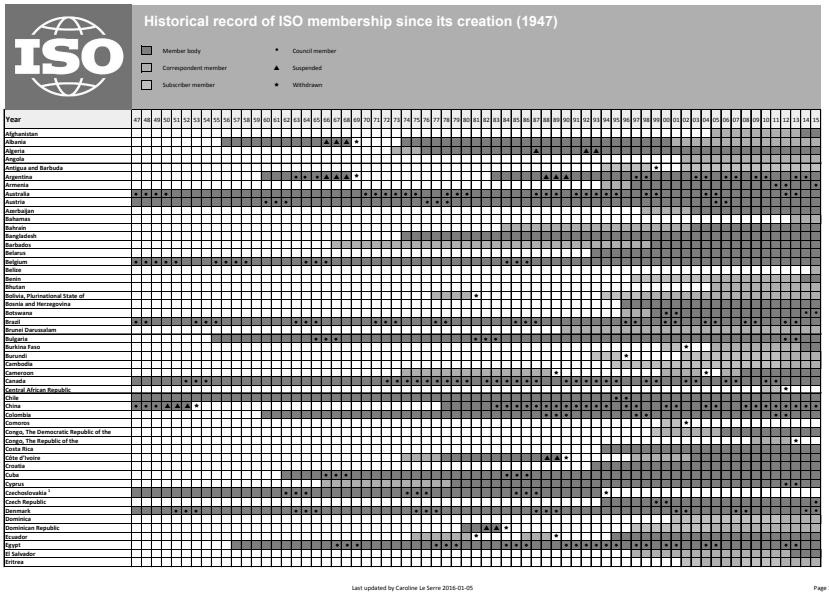


Figure A.1: PDF file of historical membership in ISO.

Certification datasets

The "Certification" datasets are created from the ISO Survey. The ISO Survey is listed among ISO's public documents and are composed of several different excel files. The process thus included reading the excel files into R, parsing the data and cleaning to ensure consistency across years and make a tidy dataframe.

Per 2023, the surveys can be found at this link[1]. The excel documents are composed of several sheets for each continent, and variously disaggregated by country, industry and country-industry over the years. Parsing thus ensures consistency as the datasets are gathered into three tidy dataframes - one for countries, one for industries and one for country-industries.

A.0.2 Validation of the "TC-membership" datasets

For participation in technical committees for both countries (member bodies) and organizations (liaison), imputations have been made based on the following rule:

- If Country/Organization A has been a P-member or O-member in technical committee B in year Y-1 and Y+1, but year Y is missing, then impute for year Y that Country/Organization A is P-member or O-member of technical committee B.
- If Country/Organization A has been P-member in year Y+2 and O-member in year Y-2, then sequentially impute that A is O-member in Y-1, then P-member in Y+1, then O-member in Y, starting at the past values.
- If Country/Organization A is P-member or O-member in Y-1 but no other information is available, then do not impute anything.

This rule has the advantage of filling in space between two years where a country or organization is a member of a TC, but there are missing values in the middle. The rule is based on the assumption that missing values between two years of membership in the same TC are due to Wayback's uneven snapshot of webpages, and not due to the country or organization stepping out of the TC for the time period and then stepping back in. The assumption also holds that the country or organization switches membership halfway between two values if the membership type in Y-2 and Y+2 is different. While none of these assumptions are likely to hold true all the time, the validation below shows that the assumptions hold most of the time.

[1] https://www.iso.org/committee/54998.html?t=KomURwikWDLiuB1P1c7SjLMLEAgXOA7emZHKGWyn
isodocuments-top

Face validity

Figure A.2 and A.3 show the amount of imputations for each country and organization over time. Separate files were made for each country and organization to view the imputations of TC membership and check for discrepancies. While face validity is a weak measure of validity in itself, it is a good first stage to gauge the validity of the imputations. The figures below show that the amount of imputations for the countries and organizations are not extreme. Because the number of organizations is a lot higher than the number of countries, names on the Y-axis were removed in the organization plot. Separate files for each country and organization are available upon request and show the same patterns as figure A.2 and A.3.

For the remaining two validation procedures, the country dataset has been validated as access to country membership is more available than organizations in liaison. However, given that the two procedures of gathering data are similar, the validity results should hold for both the country dataset and the organization dataset.

Figure A.2: Imputation of countries' participation in technical committees for Wayback data.

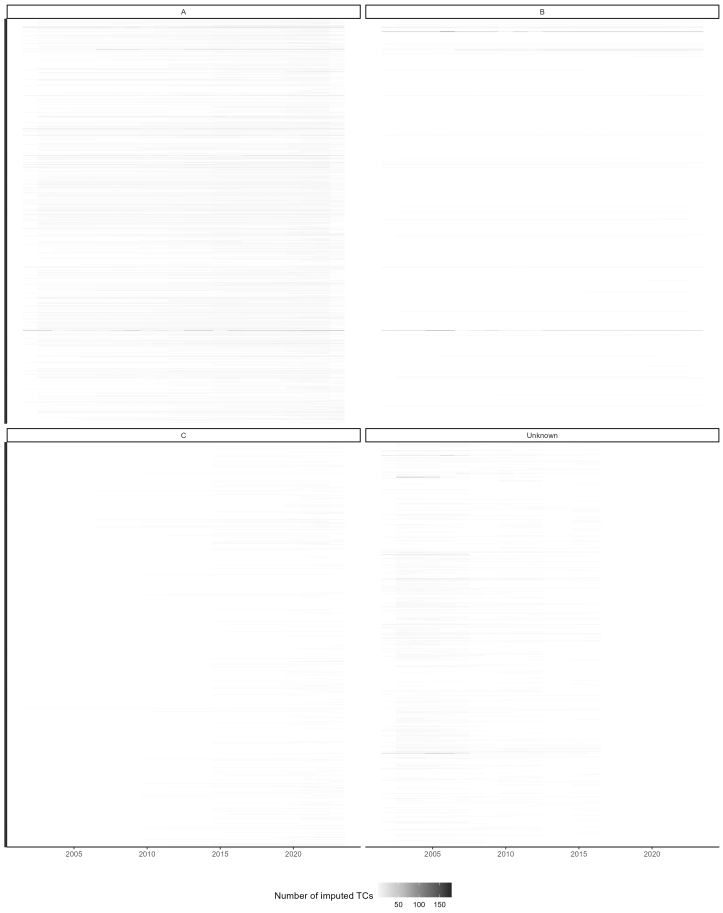


Figure A.3: Imputation of organizations' participation in technical committees for Wayback data.

Validation against public documents

There are occasional documents on technical committees on the internet, for example public reports, papers or presentations prepared by the secretariat in relation to a meeting. I use a selection of five reports that I could find to validate the participation in various technical committees. These reports are:

- **2002:** A UN paper prepared for the *Eighth United Nations Conference on the Standardization of Geographical Names* from ISO/TC 211, Geographic Information Standards. Prepared by Olaf Østensen, Chairman ISO/TC 211 Geographic information/Geomatics, and Chairman, Joint Steering Group on Spatial Standardization and Related Interoperabiltiy (E/CONF.94/1).
- **2010:** A presentation prepared by Bob Page entitled "ISO Standards as a Contribution to Global Carbon Regimes (MRV)" for the 10th annual workshop on GHG training, specifically on TC 207.
- **2016:** A powerpoint presentation entitled "Report of the Secretariat of ISO/TC 34/SC 3 "Fruits and vegetables and their derived products". They list participants in TC 24/SC 3.
- **2016:** A paper entitled "Workplace air quality: International consensus standards" published in *J Occup Environ Hyg.* 13(7) by Eun Gyung Lee, Kevin Ashley, Dietmar Breuer, Michael J. Brisson, Martin Harper, and Christian Thom. They mention TC 146/SC 2.
- **2019:** A report prepared by Jouko Vaskimo entitled "ISO/TC 258, ISO Technical Committee for Project, Program, and Portfolio Management, convenes in Seoul, South Korea" published in PM World Journal. It lists participants in TC 258.

The results of the validation against these reports can be found in table A.1. In general, the accuracy is above 80 percent. There are more false negatives in the beginning of the time series. Indeed, in 2002 there were only a few webpages to draw from and no imputations could be made, as there were no previous years to infer from. In the latter part of the time series, the risk is larger for false positives, as imputations might have caused some countries to be erronously classified as participants (P-members or O-members) in a technical committee. However, the overall improvement in accuracy shows that the imputations usually are correct.

Technical committee	Year	Membership	False negative	False positive	Accuracy	Countries in committee
TC 211	2002	P-member	23	0	20.69	6
TC 211	2002	O-member	17	0	37.04	10
TC 207	2010	P-member	2	6	89.33	73
TC 207	2010	O-member	3	2	83.33	33
TC 146/SC 2	2016	P-member	0	0	100.00	23
TC 146/SC 2	2016	O-member	0	2	88.89	18
TC 34/SC 3	2016	P-member	1	1	91.67	23
TC 34/SC 3	2016	O-member	1	2	94.23	51
TC 258	2019	P-member	4	6	75.61	37
TC 258	2019	O-member	0	2	87.50	14

Table A.1: Accuracy of StanDat based on checks against reports.

Validation against ANSI webpage - United States Secretariats

The United State standardization organization, ANSI, has comprehensive webpages. Using the Wayback Machine, I download ANSI's webpages showing US-held secretariats back to 2002. Figure A.4 shows the secretariats that were listed in ANSI's webpages divided by whether they were captured in the StanDat database. In total, 1051 out of 1353 secretariats were captured throughout the timeseries, making an accuracy of 78,7. However, most of the missing secretariats are in the beginning of the time series, when data was scarce. Starting the time series from 2004 bumps the accuracy up to 85,8.

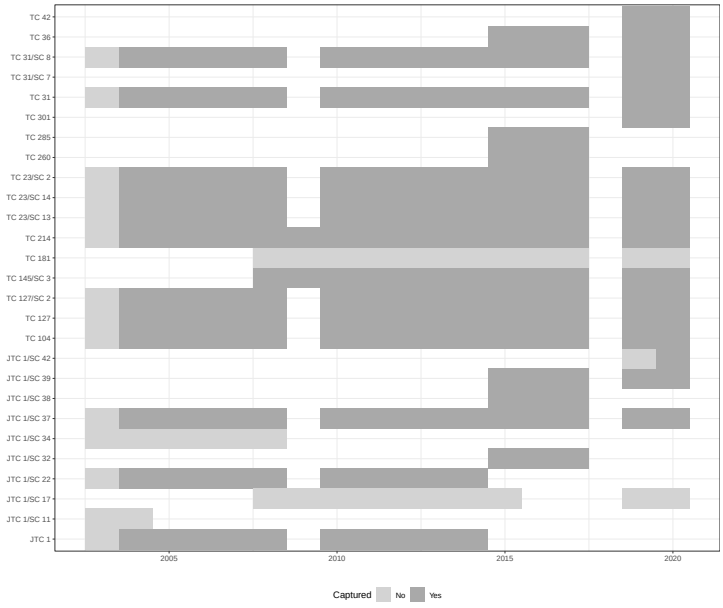
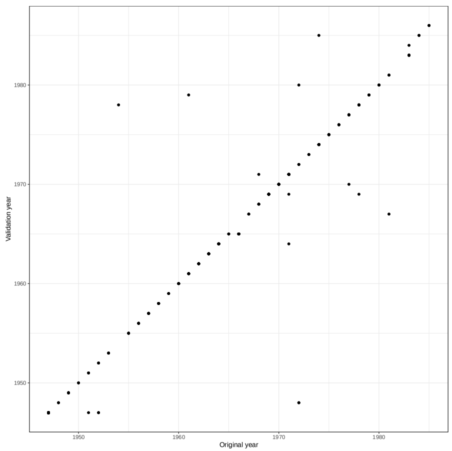


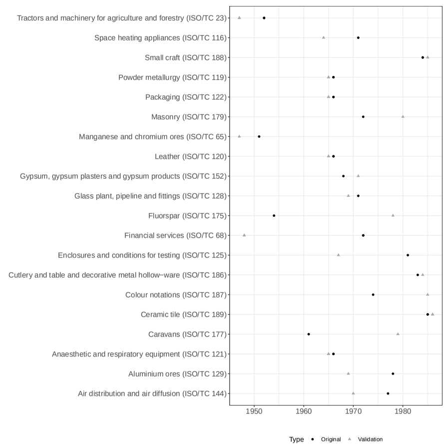
Figure A.4: Secretariats listed at ANSI's webapges and captured in StanDat.

A.0.2.1 Validation of TC establishment

The dataset "TC establishment" under "Historical" was computed by extracting all technical committees ever reported both at ISO's webpage and from other sources. Then, to compute the year of establishment for sources that were not gathered through ISO, I use ChatGPT. This has the advantage of quickly computing the years for several TCs where the information is on the internet somewhere, without having to manually search for and add these years. However, the method is not without fault. Thus, here I validate the ChatGPT codings against a report from the U.S. Department of Commerce in 2000. The report contains a list of TCs and their establishment year. Of in total 1098 TCs in my dataset, the report mentions 296. Of these, 28 TCs were coded wrong. Of all the TCs, ChatGPT misses the mark by 0,14 years. Among the wrongly coded TCs, the average miss is 1,43 years. Table A.5 gives an overview of the validation.



(a) Relationship between all TC establishment years in original dataset and validation dataset.



(b) Difference in year against the TCs where original and validation establishment year differs.

Figure A.5: Validation of TC establishment year.

A.0.3 Example of analysis assessing scope conditions of certifications

In 2001, Corbett and Kirsch (2001) published a study asking which factors that drive certification within the newly published ISO 14000 series on Environmental Management. Relying on interviews from practitioners, they hypothesized that variables such as a country's environmental orientation and previous certification in the older management standard series, ISO 9000 on Quality Management, would predict certification[2]. Using regression analysis, they found that more ISO 9000 certification (relative to GDP) is positively associated with more ISO 14000 certification (relative to GDP). Replicating this study using tree-based models, Vastag (2004) find similar patterns; ISO 9000 certification is an important predictor for ISO 14000 certification. A debate regarding the methodological choices ensued (Corbett & Kirsch, 2004), but the data foundation was not discussed. This is understandable given the early date of these studies, where parsing the ISO Survey was possibly even more challenging, and few years were available to study. Their analysis stretches from 1993 to 1998, covering 63 countries. Using the StanDat database, I extend the analysis of Corbett and Kirsch (2001) to 230 countries over 28 years, and also include another ISO series; ISO/IEC 27001 on Information Security Management Systems. I use a fixed effects linear regression model employing many of the same control variables as Corbett and Kirsch (2001), and cluster the standard errors by country-year.

Table A.2 shows the models. The first model reaffirms the patterns found by Corbett and Kirsch (2001) and Vastag (2004), even when extending the sample and including fixed effects, certification in ISO 9001 is significantly positively associated with certification in ISO 14001. However, as shown in the next two models, the association between ISO 9001 certification and ISO 14001 certification is weaker, and only previous certification within ISO 14001 is significantly and positively associated with ISO/IEC 27001 certification. This implies that the similarity between ISO 9000 and ISO 14000 found by Corbett and Kirsch (2001) does only partly extend to ISO/IEC 27001, implying that the drivers or certification infrastructure may differ more between ISO/IEC 27001 and the other two. As pointed out by Fomin et al. (2008) when suggesting some explanations for a low adoption rate of ISO/IEC 27001 compared to ISO 9001, the latter often brings relatively clear benefits such as improved market share and reduced costs, while the first aims to prevent security failures and to mitigate their consequences, where the benefit is less obvious in a day-to-day practice.

However, the findings could partly be explained by the time difference between the publication of ISO 9001 (1993) and ISO/IEC 27001 (2006), which means that

[2](Corbett & Kirsch, 2001) study certification within the complete ISO 9000 series, not only the main standard ISO 9001. Yet, the series on Quality Management is mainly represented by ISO 9001 and Environmental Management by ISO 14001, which is why I refer to ISO 9001 and ISO 14001 in this article.

by the time ISO/IEC 27001 was introduced, many organizations were already ISO 9001 certified many years ago. Given the longer time series, this is something to take into account in the new models. Table A.3 gives some credibility to this notion, showing that when using the *cumulative* number of certification as a share of GDP, ISO 9001 and ISO 14001 are both significantly and positively associated with ISO/IEC 27001 certification[3]. As such, this simple analysis may bring a humble addition to the literature on some of the most popular ISO series; ISO/IEC 27001, ISO 14001 and ISO 9001 (Culot et al., 2021; Heras-Saizarbitoria & Boiral, 2013). More generally, this brief analysis shows how the StanDat database can help scholars extend analyses to a wider population, as well as investigating whether relationships found for one specific standard series holds for other series.

[3]Carry-over counts from previous years when counting the cumulative numbers of certifications leads to a slightly higher number of observations in table A.3 than in table A.2.

	Dependent variable: Certifications		
	ISO 14001	ISO 27001	ISO 27001
Certification in ISO 9001 (1 year lag)	0.157**	0.009	−0.011*
	0.041	0.006	0.004
Certification in ISO 14001 (1 year lag)			0.101***
			0.020
GDP per capita	180.561	9.580	9.975
	121.638	10.391	8.413
Exports per GDP (ln)	0.197**	0.054**	0.032**
	0.055	0.017	0.009
Industry value added (% of GDP)	−0.003+	0.000	0.000
	0.002	0.001	0.000
Num.Obs.	3769	2321	2321
RMSE	0.24	0.04	0.03
Time series	1999-2022	2006-2022	2006-2022

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001

Table A.2: Relationship between certification in T-1 and T for various ISO series.

	Dependent variable: Certifications		
	ISO 14001	ISO 27001	ISO 27001
Cumulative certification in ISO 9001 (1 year lag)	0.023***	0.024***	0.001
	0.003	0.005	0.005
Cumulative certification in ISO 14001 (1 year lag)			0.088***
			0.015
GDP per capita	−30.969	144.043	70.861
	42.336	89.780	48.630
Exports per GDP (ln)	0.048+	0.013	0.007
	0.028	0.033	0.023
Industry value added (% of GDP)	0.001	0.001	0.001*
	0.001	0.001	0.001
Num.Obs.	3771	2738	2738
RMSE	0.21	0.14	0.12
Time series	1999-2022	2006-2022	2006-2022

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001

Table A.3: Relationship between cumulative certification in T-1 and T for various ISO series.

A.0.4 Example of analysis on standardization and patents

Much research has been conducted on the role of standards in innovation. One question entails whether standards have a positive or negative effect on innovation, finding that under certain conditions, standardization seems to enhance innovation (Acemoglu et al., 2012; Allen & Sriram, 2000; Blind et al., 2017). There are indications suggesting a similar phenomenon with ISO standards as well (Manders et al., 2016), though there remains a need for further research examining cross-country variations in innovation and ISO certification (Lim & Prakash, 2014).

Yet another question asks not whether the adoption of standards enhances innovation, but whether standardization may be a goal for innovators. This question probes the motives of standardizers in enhancing patented technology, and may in fact be one of the reasons why countries want to participate in TCs (Blind & von Laer, 2022). Many scholars have studied the role of standard-essential patents (SEP), i.e. when patented technology becomes an essential part of a standard (Lerner & Tirole, 2015). However, the relationship between patented technology and participating in standardization is difficult to quantify, as studies suggest that there is a significant overdeclaration of SEPs, while at the same time, only a subgroup of patented technology relevant to a standard is usually reported (Depoorter et al., 2019). Thus, scholars have been working on other ways of mapping patents to standards (Baron & Pohlmann, 2018; Brachtendorf et al., 2023).

One approach could be to map patent classification (IPC) to TCs. In this small illustration on exploring the relationship between standardization and innovation, I follow that approach. This example focuses on ICT technology, a fast-paced technology area where the role of standardization for innovation has been particularly questioned (Teece, 2018). Using a detailed concordance table in an OECD report (Inaba & Squicciarini, 2017), I map standards on ICT technology to ISO/IEC JTC 1, the most general TC within information technology. In doing this, I merge StanDat's TC-membership dataset with data on patents registered at the United States Patent and Trademark Office (USPTO) (Toole et al., 2021) by country-year[4]. The question is whether being part of this major TC within ICT is associated with more patent output in that technology area[5]. Patents are measured in fractional counts (Blind & von Laer, 2022; Frietsch & Schmoch, 2010).

[4]While there may be bias in data gathered from national patent offices, since application and granting processes vary (Frietsch & Schmoch, 2010), the USPTO database has been found to be among the most reliable in terms of quantifying innovation activity (Kim & Lee, 2015). Another advantage of this database is that it contains very recent data, allowing for long time series.

[5]The technology area includes high speed network, mobile communication, digital security, sensor and device network, high speed computing, large capacity high speed storage, cognition and meaning understanding, human interface, imaging and sound technology, information communication devices, electronic measurement, and a residual category.

The analysis in table A.4 shows that membership in ISO/IEC JTC 1 is significantly associated with a larger output of patents within ICT technology. For example, for the United States in 2015, the estimated number of ICT patents if the country was not a member would be 6000, compared to an estimated 15500 upon being a member of ISO/IEC JTC 1. While the model includes country-year fixed effects, the direction of the causal effect may go both ways – innovation activity can lead to TC membership, and TC membership may enhance innovation activity. Interestingly, this relation is not distinguishable for P-members or O-members, indicating that being active in the process does not equate more patents – merely observing the negotiations might suffice.

	Dependent variable: Number of ICT patents	
	TC membership	Type of membership
Membership in TC	0.948**	
	0.367	
P-member in TC		0.347
		0.227
GDP per capita	0.000	0.000
	0.000	0.000
Industry value added (% of GDP)	−0.061*	−0.062*
	0.029	0.029
ICT % of service exports	0.033*	0.032*
	0.016	0.016
Num.Obs.	1107	936
RMSE	679.85	739.16
Time series	2004-2022	2004-2022

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001
Fixed effects: Country and year.
Clustered standard errors by country and year.
Model: Poisson.

Table A.4: Relationship between membership in ISO/IEC JTC 1 and number of ICT patents.

A.0.5 Robustness checks for Table I.4

Table I.4 showing control variables.

Table A.5 shows all control variables for the main analysis.

	Dependent variable: ln(Dyadic trade) (UN Comtrade)				
	Baseline	Gravity	Gravity+R&D	Gravity+	Gravity++
ln(TC connections)	0.073***	0.084***	0.057***	0.036*	0.031
	(0.014)	(0.017)	(0.013)	(0.016)	(0.019)
Patents (exporter) as share of GDP			−0.013**		
			(0.003)		
Patents (importer) as share of GDP			−0.005**		
			(0.001)		
Regional trade agreement		−0.040	−0.093*	−0.069	−0.125+
		(0.042)	(0.040)	(0.041)	(0.056)
WTO dyad		−0.122**	−0.169**	−0.073	−0.112
		(0.040)	(0.044)	(0.061)	(0.110)
Democratic dyad				−0.002	0.008
				(0.026)	(0.027)
Preferential trade agreement				0.020	0.016
				(0.045)	(0.039)
Common currency				−0.172*	−0.178*
				(0.072)	(0.073)
Alliance					−0.022
					(0.076)
Strategic rivals					0.037
					(0.070)
Num.Obs.	402 385	346 684	229 574	190 173	125 511
RMSE	1.38	1.38	1.26	1.25	1.14
Controls	No	Gravity	Gravity+R&D	Gravity+	Gravity++
Time series	2004-2022	2004-2021	2004-2021	2004-2015	2004-2011

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Fixed effects by dyad, country and year, clustered standard errors by dyad and year.

Zero imputation on dyads with missing on TC connections.

Table A.5: Control variables for main analysis.

Table I.4 using trade flow data from IMF

Table I.4 made use of trade date from UN Comtrade. Table A.6 shows that results are quite similar when using trade data from IMF instead, although this results in less data points, as the IMF data ends in 2020. The last two models give quite weak and insignificant coefficients, indicating that states' goodwill towards each other, measured in terms of democratic dyad, preferential trade agreements or common currency, may account for some of the effect of joint TC membership on trade.

	Dependent variable: ln(Dyadic trade) (IMF).				
	Baseline	Gravity	Gravity+R&D	Gravity++	Gravity+++
ln(TC connections)	0.051**	0.053**	0.035**	0.004	−0.016
	0.014	0.014	0.011	0.015	0.020
Patents (exporter) as share of GDP			−0.013***		
			0.003		
Patents (importer) as share of GDP			−0.008*		
			0.003		
Regional trade agreement		−0.072	−0.099*	−0.073	−0.129*
		0.045	0.043	0.045	0.053
WTO dyad		−0.053	−0.083+	−0.071	−0.125
		0.042	0.043	0.047	0.082
Democratic dyad				0.009	0.001
				0.032	0.029
Preferential trade agreement				0.004	0.002
				0.050	0.046
Common currency				−0.154*	−0.135
				0.068	0.074
Alliance					−0.053
					0.059
Strategic rivals					0.022
					0.084
Num.Obs.	298 659	298 659	205 630	181 238	118 944
RMSE	1.29	1.29	1.18	1.18	1.07
Controls	No	Gravity	Gravity+R&D	Gravity+	Gravity++
Time series	2004-2020	2004-2020	2004-2020	2004-2015	2004-2011

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Fixed effects: Dyad, country and year.

Clustered standard errors by dyad and year.

Zero imputation on dyads with missing on TC connections.

Table A.6: Using IMF trade data for dependent variable.

Table I.4 using *share of trade* as dependent variable

Table I.4 used as the dependent variable the total trade between countries in a given year (log transformed). Some scholars, e.g. Blind and von Laer (2022), use share of trade instead. Table A.7 shows that the results are robust to such a specification.

	Dependent variable: Share of trade				
	Baseline	Gravity	Gravity+R&D	Gravity++	Gravity+++
ln(TC connections)	0.000 29*	0.000 30*	0.000 42*	0.000 50*	0.000 64*
	0.000 12	0.000 12	0.000 16	0.000 18	0.000 24
Patents (exporter) as share of GDP			−0.000 02+		
			0.000 01		
Patents (importer) as share of GDP			0.000 00		
			0.000 00		
Regional trade agreement		0.000 43*	0.000 52*	0.000 52*	0.000 62*
		0.000 16	0.000 20	0.000 19	0.000 22
WTO dyad		−0.000 11	−0.000 11	0.000 13	0.000 33
		0.000 22	0.000 26	0.000 35	0.000 19
Democratic dyad				−0.000 04	−0.000 04
				0.000 05	0.000 05
Preferential trade agreement				0.000 32	0.000 14
				0.000 45	0.000 35
Common currency				−0.000 10	0.000 03
				0.000 19	0.000 21
Alliance					0.002 33
					0.001 48
Strategic rivals					−0.005 18+
					0.002 54
Num.Obs.	402 385	346 684	229 574	190 173	125 511
RMSE	0.01	0.01	0.01	0.01	0.01
Controls	No	Gravity	Gravity+R&D	Gravity+	Gravity++
Time series	2004-2022	2004-2021	2004-2021	2004-2015	2004-2011

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001
Fixed effects: Dyad and year.
Clustered standard errors by dyad and year.
Zero imputation on dyads with missing on TC connections.

Table A.7: Using share of trade as dependent variable.

Table I.4 using a dichotomous independent variable

While the quantity of TC connections may be meaningful, another question is if sharing a TC membership in itself goes together with more trade. Table A.8 shows that using TC membership as a dichotomous variable does not alter results.

	Dependent variable: Presence of TC membership (binary) (UN Comtrade)				
	Baseline	Gravity	Gravity+R&D	Gravity++	Gravity+++
Presence of TC connection	0.147***	0.177***	0.159***	0.137**	0.085+
	(0.031)	(0.038)	(0.029)	(0.033)	(0.041)
Patents (exporter) as share of GDP			−0.013**		
			(0.003)		
Patents (importer) as share of GDP			−0.005**		
			(0.001)		
Regional trade agreement		−0.037	−0.096*	−0.069	−0.124+
		(0.043)	(0.041)	(0.039)	(0.056)
WTO dyad		−0.116*	−0.169**	−0.072	−0.110
		(0.041)	(0.045)	(0.062)	(0.110)
Democratic dyad				−0.001	0.008
				(0.027)	(0.027)
Preferential trade agreement				0.018	0.016
				(0.045)	(0.039)
Common currency				−0.202*	−0.191*
				(0.072)	(0.078)
Alliance					−0.018
					(0.076)
Strategic rivals					0.031
					(0.070)
Num.Obs.	402 385	346 684	229 574	190 173	125 511
RMSE	1.38	1.38	1.26	1.25	0.01
Controls	No	Gravity	Gravity+R&D	Gravity+	Gravity++
Time series	2004-2022	2004-2021	2004-2021	2004-2015	2004-2011

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Fixed effects: Dyad and year.

Clustered standard errors by dyad and year.

Table A.8: Using a dichotomous independent variable.

Table I.4 using country fixed effects

Table I.4 used a rigorous high-dimensional fixed effects model which can be quite restrictive. Table A.9 shows that the coefficients remain significant in the same direction when loosening up the fixed effects model by only controlling for country-year.

	Dependent variable: ln(Dyadic trade) (UN Comtrade)				
	Baseline	Gravity	Gravity+R&D	Gravity++	Gravity+++
ln(TC connections)	0.490***	0.383***	0.248***	0.149**	0.026
	(0.053)	(0.051)	(0.049)	(0.041)	(0.041)
Patents (exporter) as share of GDP			−0.015*		
			(0.005)		
Patents (importer) as share of GDP			−0.005*		
			(0.002)		
Regional trade agreement		2.105***	1.954***	2.362***	1.564***
		(0.149)	(0.151)	(0.157)	(0.140)
WTO dyad		0.371*	0.164	0.408*	0.752*
		(0.146)	(0.112)	(0.184)	(0.239)
Democratic dyad				0.193*	0.109
				(0.076)	(0.068)
Preferential trade agreement				0.823**	0.432+
				(0.227)	(0.225)
Common currency				1.125*	0.419
				(0.394)	(0.406)
Alliance					1.877***
					(0.154)
Strategic rivals					1.426*
					(0.499)
Num.Obs.	402 385	346 684	229 574	190 173	125 511
RMSE	2.57	2.51	2.34	2.34	2.21
Controls	No	Gravity	Gravity+R&D	Gravity+	Gravity++
Time series	2004-2022	2004-2021	2004-2021	2004-2015	2004-2011

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Fixed effects: Country 1, country 2 and year.
Clustered standard errors by country 1, country 2 and year.
Zero imputation on dyads with missing on TC connections.

Table A.9: Using country-year fixed effects, excluding dyad-fixed effects.

Table I.4 using region fixed effects

In testing for an even less rigorous restriction, table A.10 shows that the results hold also when controlling for region-year.

	Dependent variable: ln(Dyadic trade) (UN Comtrade)				
	Baseline	Gravity	Gravity+R&D	Gravity++	Gravity+++
ln(TC connections)	1.416***	1.263***	1.274***	1.076***	1.061***
	(0.052)	(0.037)	(0.065)	(0.038)	(0.037)
Patents (exporter) as share of GDP			−0.046		
			(0.029)		
Patents (importer) as share of GDP			−0.007		
			(0.004)		
Regional trade agreement		1.366**	1.434**	1.847***	1.423**
		(0.327)	(0.276)	(0.281)	(0.282)
WTO dyad		0.975**	0.431*	0.374*	0.413+
		(0.225)	(0.142)	(0.129)	(0.184)
Democratic dyad				−0.053	−0.052
				(0.147)	(0.116)
Preferential trade agreement				0.547+	0.216
				(0.240)	(0.143)
Common currency				0.924	0.505
				(0.588)	(0.631)
Alliance					1.198*
					(0.393)
Strategic rivals					1.940*
					(0.662)
Num.Obs.	399 046	344 892	229 574	190 173	125 511
RMSE	3.27	3.22	3.02	3.10	3.06
Controls	No	Gravity	Gravity+R&D	Gravity+	Gravity++
Time series	2004-2022	2004-2021	2004-2021	2004-2015	2004-2011

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001
Fixed effects: Region for country 1, region for country 2 and year.
Clustered standard errors by region for country 1, region for country 2 and year.
Zero imputation on dyads with missing on TC connections.

Table A.10: Using region-year fixed effects. Excluding dyad and country fixed effects.

Table I.4 using 5-year period fixed effects

The results in table A.11 further tests for over-controlling by using dyad-period-fixed effects. The results hold to this specification.

	Dependent variable: ln(Dyadic trade) (UN Comtrade)				
	Baseline	Gravity	Gravity+R&D	Gravity++	Gravity+++
ln(TC connections)	0.121**	0.145**	0.083**	0.073*	0.069
	(0.022)	(0.028)	(0.017)	(0.020)	(0.039)
Patents (exporter) as share of GDP			−0.014		
			(0.007)		
Patents (importer) as share of GDP			−0.009+		
			(0.003)		
Regional trade agreement		−0.084	−0.161+	−0.024	−0.162
		(0.080)	(0.063)	(0.041)	(0.080)
WTO dyad		−0.077	−0.132	−0.097	−0.039
		(0.089)	(0.097)	(0.098)	(0.112)
Democratic dyad				−0.064	0.004
				(0.052)	(0.047)
Preferential trade agreement				0.050	0.036
				(0.057)	(0.077)
Common currency				−0.225*	−0.302*
				(0.070)	(0.063)
Alliance					−0.026
					(0.094)
Strategic rivals					−0.028
					(0.197)
Num.Obs.	127 945	99 013	59 849	70 600	51 975
RMSE	1.18	1.17	1.05	1.06	0.91
Controls	No	Gravity	Gravity+R&D	Gravity+	Gravity++
Time series	2004-2022	2004-2021	2004-2021	2004-2015	2004-2011

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001
Fixed effects: Region for dyad and 5-year period.
Clustered standard errors by dyad and 5-year period.
Zero imputation on dyads with missing on TC connections.

Table A.11: Using region-dyad and 5-year period fixed effect.

Table I.4 without zero imputation on dyads with missing on TC connection

Table I.4 had imputations of zero on dyads that sported no TC connection. This is because when constructing a network, dyads with no edge will not be included in the dataset. Since the ISO webpage lists all countries that participate in TCs, it is natural to assume that they have no TC connection when this is missing. Table A.12 runs the regression without imputations. The main results remain, except that the coefficient when controlling for R&D intensity becomes insignificant, as mentioned in the article.

	Dependent variable: ln(Dyadic trade) (UN Comtrade)				
	Baseline	Gravity	Gravity+R&D	Gravity++	Gravity+++
ln(TC connections)	0.059***	0.063***	0.029+	0.082**	0.060+
	(0.013)	(0.014)	(0.015)	(0.020)	(0.028)
Patents (exporter) as share of GDP			−0.014**		
			(0.004)		
Patents (importer) as share of GDP			−0.012**		
			(0.004)		
Regional trade agreement		−0.024	−0.026	−0.060	−0.176+
		(0.034)	(0.031)	(0.049)	(0.085)
WTO dyad		−0.135+	−0.167*	−0.095	−0.097
		(0.075)	(0.075)	(0.091)	(0.115)
Democratic dyad				−0.026	0.016
				(0.032)	(0.035)
Preferential trade agreement				0.010	0.010
				(0.049)	(0.045)
Common currency				−0.060	−0.060
				(0.061)	(0.061)
Alliance					−0.008
					(0.076)
Strategic rivals					−0.016
					(0.083)
Num.Obs.	176 104	148 518	129 778	81 490	46 951
RMSE	1.05	1.06	0.99	0.94	0.84
Controls	No	Gravity	Gravity+R&D	Gravity+	Gravity++
Time series	2004-2022	2004-2021	2004-2021	2004-2015	2004-2011

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001

Fixed effects: Dyad and year.

Clustered standard errors by dyad and year.

Table A.12: Without zero imputations on TC connection.

Table I.4 with patents data from the World Intellectual Property Organization (WIPO)

The models in table I.4 used data from PatentsView, which is based on data from the U.S. Patent & Trademark Office (USPTO). While USPTO is found to be the most appropriate patent database for studies on global innovation patterns (Kim & Lee, 2015). However, as with any national registration office, it may be biased towards domestic residents or likewise. Therefore, table A.13 illustrates how the results in models in table I.4 are consistent using patent data from WIPO instead of USPTO.

	Dependent variable: ln(Dyadic trade) (UN Comtrade)				
	Baseline	Gravity	Gravity+R&D	Gravity+	Gravity++
ln(TC connections)	0.073***	0.084***	0.056***	0.036*	0.031
	(0.014)	(0.017)	(0.011)	(0.016)	(0.019)
Patents (exporter) as share of GDP			0.000		
			(0.001)		
Patents (importer) as share of GDP			−0.001		
			(0.001)		
Regional trade agreement		−0.040	0.004	−0.069	−0.125+
		(0.042)	(0.028)	(0.041)	(0.056)
WTO dyad		−0.122**	−0.082	−0.073	−0.112
		(0.040)	(0.060)	(0.061)	(0.110)
Democratic dyad				−0.002	0.008
				(0.026)	(0.027)
Preferential trade agreement				0.020	0.016
				(0.045)	(0.039)
Common currency				−0.172*	−0.178*
				(0.072)	(0.073)
Alliance					−0.022
					(0.076)
Strategic rivals					0.037
					(0.070)
Num.Obs.	402 385	346 684	141 426	190 173	125 511
RMSE	1.38	1.38	1.02	1.25	1.14
Controls	No	Gravity	Gravity+R&D	Gravity+	Gravity++
Time series	2004-2022	2004-2021	2004-2021	2004-2015	2004-2011

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Fixed effects by dyad, country and year, clustered standard errors by dyad and year.

Zero imputation on dyads with missing on TC connections.

Table A.13: With only Gravity controls, but same time series.

Table I.4 with only Gravity controls, but same time series

The models in table I.4 had a smaller time series when including control variables, due to the availability of data. To check whether the results might be driven by smaller time series rather than the inclusion of the extra control variables, table A.14 shows models with shorter time series without the given control variables. The coefficient for TC connections is significant and positive across specifications, indicating that the coefficient is rendered insignificant in the primary models due to the control variables, and not the shorter time series.

	Dependent variable: ln(Dyadic trade) (UN Comtrade)				
	Baseline	Gravity	Gravity+R&D	Gravity	Gravity
ln(TC connections)	0.073***	0.084***	0.057***	0.071**	0.056*
	(0.014)	(0.017)	(0.013)	(0.017)	(0.021)
Patents (exporter) as share of GDP			−0.013**		
			(0.003)		
Patents (importer) as share of GDP			−0.005**		
			(0.001)		
Regional trade agreement		−0.040	−0.093*	−0.174**	−0.228**
		(0.042)	(0.040)	(0.055)	(0.055)
WTO dyad		−0.122**	−0.169**	−0.071	−0.085
		(0.040)	(0.044)	(0.051)	(0.093)
Num.Obs.	402 385	346 684	229 574	228 249	150 324
RMSE	1.38	1.38	1.26	1.29	1.18
Controls	No	Gravity	Gravity+R&D	Gravity	Gravity
Time series	2004-2022	2004-2021	2004-2021	2004-2015	2004-2011

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Fixed effects by dyad, country and year, clustered standard errors by dyad and year.

Zero imputation on dyads with missing on TC connections.

Table A.14: With patent data from WIPO.

Table I.4 using a Generalized Methods of Moments model

The Generalized Method of Moments (GMM) models are often used for dynamic panel data where the number of groups is smaller than the time series, when the researcher wants to control for endogeneity. Because GMM models allows the moments conditions to exceed the number of parameters, the researcher can include lagged dependent variables as internal instruments along with lagged dependent variables as regressors, essentially controlling for the persistence of the dependent variable (Arellano & Bond, 1991). This technique, though not immune to critique given its reliance on a set of strong assumptions, remains widely adopted by numerous researchers, particularly those within the field of economics, as a means to elucidate causal relationships when the dependent variable exhibits high persistence. In this specification, I use the System GMM estimator, as this has been shown to be more robust for unbalanced panels than the difference estimator (Blundell & Bond, 1998).

Because the inclusion of time dummies sometimes creates a singular matrix which prevents the estimation, the second and third model incorporates only dyad-fixed effects. While many of the models do show a significant coefficient for TC connections, the direction of the coefficient varies. Moreover, only the Gravity++ model has remotely valid instruments, according to the Sargan-Hansen test[6]. In this model, the coefficients for TC connections are invalid, leading to the conclusion that there is no clear indication that causality goes from joint TC membership to larger trade volumes.

[6]Neither the model Gravity++, not any of the other models, actually pass the Sargan-Hansen test, having p-values above 0.05. This is typical for models with a high number of observations, and may not necessarily mean that the instruments are invalid (Kiviet & Kripfganz, 2021), but should still be considered a weakness.

	Dependent variable: ln(Dyadic trade) (UN Comtrade)				
	Baseline	Gravity	Gravity+R&D	Gravity++	Gravity+++
Lag ln(Dyadic trade), 1	0.524***	0.638***	0.654***	0.181*	0.634***
	(0.006)	(0.004)	(0.004)	(0.091)	(0.010)
Lag ln(Dyadic trade), 2	0.237***	0.339***	0.377***	0.104***	0.366***
	(0.005)	(0.004)	(0.004)	(0.024)	(0.009)
ln(TC connections)	0.156***	0.082***	−0.049***	−0.008	0.011
	(0.009)	(0.010)	(0.011)	(0.013)	(0.016)
Lag ln(TC connections), 1	0.137***	−0.052***	−0.022*	−0.015	−0.030*
	(0.009)	(0.009)	(0.009)	(0.012)	(0.013)
Regional trade agreement		0.090***	−0.104***	0.040	−0.030+
		(0.012)	(0.008)	(0.038)	(0.015)
WTO dyad		0.393***	−0.247***	0.084+	0.003
		(0.032)	(0.026)	(0.046)	(0.012)
Patents (exporter) as share of GDP			−0.006***		
			(0.001)		
Patents (importer) as share of GDP			−0.003***		
			(0.000)		
Democratic dyad				0.038	−0.029**
				(0.025)	(0.009)
Preferential trade agreement				0.016	0.034+
				(0.016)	(0.019)
Common currency				0.008	−0.083***
				(0.041)	(0.018)
Alliance					0.004
					(0.019)
Strategic rivalry					0.067
					(0.043)
Num.Obs.	409 627	473 328	327 762	82 757	103 584
Controls	No	Gravity	Gravity+R&D	Gravity+	Gravity++
Time series	2004-2022	2004-2021	2004-2021	2004-2015	2004-2011
Fixed effects	Dyad & Year	Dyad	Dyad	Dyad & Year	Dyad & Year
Sargan-Hansen p-value	< 2.22e-16	< 2.22e-16	< 2.22e-16	0.003	4.3781e-11
Autocorrelation test (2) p-value	< 2.22e-16	< 2.22e-16	< 2.22e-16	< 2.22e-16	< 2.22e-16

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001

Clustered standard errors by dyad and year.

Model: Generalized Methods of Moments (GMM)

Table A.15: With a Generalized Methods of Moments model.

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Appendix B

Appendix for Legitimation Strategies of Transnational Private Institutions

B.0.1 GPT-coding of standard type

Prompt

> International standards are important regulatory instruments. Imagine you are an expert on international standards, asked to classify standards into either 'physical' or 'societal'.
> Physical standards: Provide technical specifications, scientific formula or ICT specifications. They ensure interchangeability and solve coordination problems. Physical standards are specific to products, materials or behaviors and focus primarily on the final results.
> Societal standards: Addresses performance, quality, safety and health in manufacturing processes. May for example address sustainable development, labour standards, CSR, management practices or the service economy. Societal standards focus on regulating the organization or system as a whole.
> The abstract of the standard reads: "X". And the ICS code of the standard is "Y".
> What type of standard is this? Pick one of the following: (1) physical, (2) societal.

Validation

I validate the GPT-coded standards using two measures. The first validation finds a positive correlation between standards coded as societal and their inclusion of a sustainable development goal (SDG), like gender equality and education, as shown in Figure B.1. The correlation is moderate since physical standards also contribute to SDGs related to infrastructure and marine life. The second validation examines the correlation between societal coding and production in a social committee as depicted in Figure II.1. This correlation is strong at 0.5, indicating that societal standards are likely produced within these committees. Yet, the absence of a one-to-one relationship underscores the need to evaluate standards individually as societal or physical.

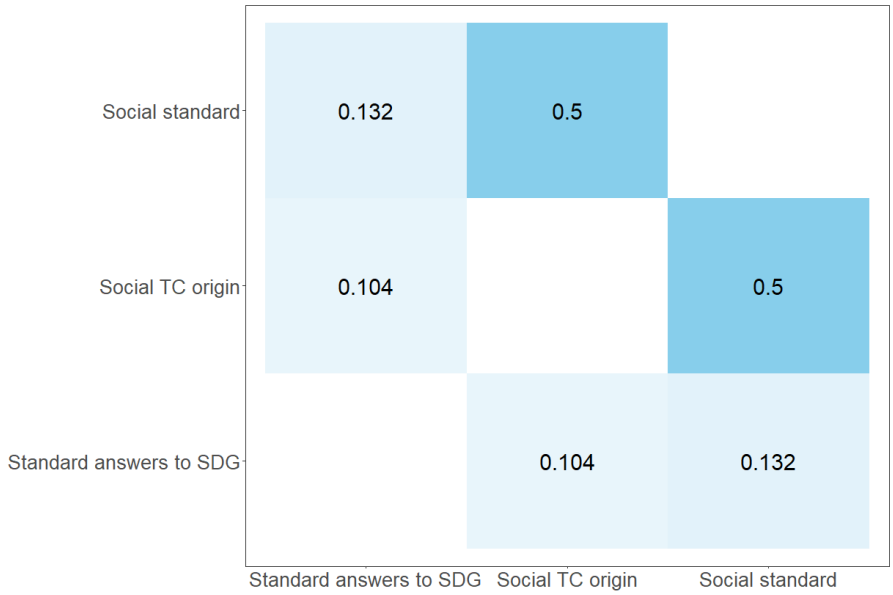

Figure B.1: Correlation between GPT-coded standard type and two measures of validation.

B.0.2 Measuring democratic input legitimation: Committee diversity

As outlined in section II.6, democratic input legitimation is measured as committee diversity. ISO itself has expressed high importance of ensuring widespread coverage of stakeholders into the committee work when producing the standards on social responsibility (K. Hallström, 2008), but this has not been a default approach, as previous studies have found that TCs tend to have an overweight of national member bodies from Western Europe (Morikawa & Morrison, 2004).

Committee diversity measures are based on the composition of participating (P-member) countries in technical committees (TCs) and subcommittees (SCs) (hereby only referred to as TCs). P-members engage actively in committee work. Observing members (O-members) are less influential, being allowed to follow the process but not participate. Thus, to capture the relevant inclusion of a diverse set of stakeholders, I study the variation among P-members in each TC. While these data document formal participation in a TC, it is important to recognize that simply being a member of a TC does not automatically equate to active participation. Some members do not possess the resources necessary to travel to meetings all over the world. Even when being physically present, meaningful involvement in negotiation processes relies on additional factors beyond formal membership, such as time and expertise (Alshadafan, 2020). The measurement is therefore a proxy that does not capture more nuanced variation in ability to contribute among participating members.

Committee diversity is measured through two different indices; the Douglas Rae's method of electoral fractionalization (Rae Index) (Rae, 1968) and the Shannon Index for species diversity (Shannon H) (Shannon, 1948). The Rae Index is similar as the inverse Herfindahl Index, and both this and Shannon H have been used to measure diversity within multiple fields of political science (Boydstun et al., 2014). To make the measure sensitive to not only skewed representation of existing regions or sectors, but also that there might be a bias in who enters the committee, I use the normalized version and base these on the potential total. Although a certain number of regions or sectors were represented in a committee (on average 3.8 regions and 2.3 sectors), the total number of available items is 5 and 10.

The Rae Index was designed to measure diversity among parties in an electoral system. Its normalized version controls for the number of available items by introducing the $1 - N$ elements. Here, $N = 5$ for regions and $N = 10$ for sectors. s_i is the share of committee seats held by each region or sector:

$$\frac{1 - \sum_{i=1}^{N} s_i^2 - \frac{1}{N}}{1 - \frac{1}{N}} \tag{B.1}$$

When controlling for the actual number of items represented, a normalized Rae

Index would vary between 0 and 1. However, because I here control for the potential total, the Rae Index takes on negative values. This is not a problem as I do not compare different populations, and the interpretation remains the same; values closer to 1 indicate high fractionalization, e.g. higher diversity of national member bodies from different regions within the committee, and conversely, a Rae Index closer to or lower than 0 means high concentration, e.g. domination by one region within the committee.

While the Rae Index measures diversity by accounting for the absence of dominance within a committee, Shannon H was designed to measure information entropy. I use the normalized version, where Shannon H is calculated as shown below. Again, N is the total potential items represented, being $N = 5$ for regions and $N = 10$ for sectors. s_i is the share of committee seats held by each region or sector. The use of the natural logarithm in the equation emphasizes the contribution of rare items.

$$\frac{-\sum_{i=1}^{N} s_i \ln(s_i)}{\ln(N)} \tag{B.2}$$

Shannon H has two advantages over the Rae Index. First, it is more sensitive to the number of regions and sectors available. For example, if a committee is dominated by one region with two other small regions present, the Rae Index may weigh the inclusion of regions higher and overestimate the diversity. Conversely, the Shannon Index will increase more as rare regions are represented, and be higher for a committee with many regions roughly equally represented than a sizable committee with a high presence of one region. Second, the Shannon Index has been found to be more sensitive and thus better at capturing changes in diversity in both low and high ends of the scale (Boydstun et al., 2014).

Table B.1 shows descriptive statistics for the measures on committee diversity.

Table B.1: Descriptive statistics for committee diversity.

	Input legitimation			
	Regional committee diversity		*Sector committee diversity*	
	Rae Index	Shannon H	Rae Index	Shannon H
Mean	0.455	0.629	0.309	0.272
Median	0.464	0.639	0.422	0.292
Max	0.727	0.982	0.826	0.829
Min	-0.250	0.000	-0.111	0.000

Regional diversity (national member bodies)

The *countrycodes* package in R was used to categorize the country origin of national member bodies into regions. The *un.region.name* classification was used, which lists countries into one of 5 different continents. The regions are listed below, along with the number of country-years that fall within each region.

Region	Number
Africa	7532
Americas	12027
Asia	13727
Europe	13936
Oceania	5626

Table B.2: Number of country-years belonging to respective regions.

A more fine-grained regional division could have been used, for example *un.regionsub.name*, which classifies countries into one of 17 different regions. Applied to this dataset, this would leave a total of 15 different regions. However, this classification would lead to lower committee-variation, as shown in table B.3. Because I use a fixed effects model that controls for committee-specific effects, low variation on the independent variable significantly reduces the efficiency of the model. Considering this, I use the categorization scheme with 5 different variables.

Table B.3: Descriptive statistics for committee diversity measures with 15 and 5 regions.

	Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
Rae Index (15 regions)	-0.07143	0.79227	0.82857	0.81590	0.85744	0.91182
Shannon Index (15 regions)	0.0000	0.6455	0.7225	0.7118	0.7896	0.9440
Rae Index (5 regions)	-0.2500	0.3833	0.4643	0.4550	0.5370	0.7266
Shannon Index (5 regions)	0.0000	0.5460	0.6394	0.6293	0.7292	0.9824

Sector diversity (liaison organizations)

The categorization scheme for liaison organizations is based on K. T. Hallström (2010) and ISO's own categorization of liaison organizations. The list of organizations was manually assessed, and the *financial institutions* and *media* categories were then added to better represent the existing organizations. There were 1266 organizations in total. These were coded using GPT-4, and were then manually checked.

The prompt sounded:

> You are an expert on various organizations, associations, and standard bodies from different industries and sectors. You are to classify organizations into their appropriate category based on the definitions below:
>
> - **Industry:** Individual firms and industry associations representing a specific industry or group of professionals.
> - **Consultant and Registrar:** Firms that provide engineering/technical services, or support or training related to standards.
> - **Standards Organizations:** Standard development organizations and accreditation bodies.
> - **Government Organizations:** National or international governmental organizations/agencies/ministries.
> - **Professional Association:** Professional groups.
> - **Research:** Research and/or academic institutions.
> - **NGO:** Non-governmental organizations, such as consumer organizations, advocacy groups, or other civil society representatives.
> - **Fiancial Institutions:** Institutions dealing with finance such as banks, insurance companies and real estate firms.
> - **Media:** Organizations dealing with public media such as TV stations, news outlets and journalistic organizations.
> - **Other:** Other organizations.

Most organizations in liaison are international or regional organizations. National organizations are normally organized through their respective national member body. Table B.4 gives an overview of the organization-years falling within each category. Table B.5 shows the variation on the diversity measures for the liaison organizations using 10 sectors.

Sector	**Number**
Consultant and Registrar	136
Financial institutions	1749
Government	7291
Industry	5854
Intergovernmental organizations	65
Media	225
NGO	2097
Other	133
Research	3787
Standards organization	3684

Table B.4: Number of organization-years belonging to respective sectors.

Table B.5: Descriptive statistics for committee diversity measures using 10 sectors.

	Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
Rae Index	-0.1111	-0.1111	0.4222	0.3090	0.5833	0.8264
Shannon H	0.0000	0.0000	0.2923	0.2722	0.4515	0.8294

B.0.3 Measuring technocratic input legitimation: Committee expertise

The measure of committee expertise is based on the same rationale as the committee diversity measure; it measures overall committee dynamics (see section B.0.2).

There are no widely acknowledged quantifiable indicators of technocratic processes, but scholars agree that the concept includes stressing of expertise, skill and unattached interest in decision-making, in order to find "optimal solutions". It "rests on a belief that objective solutions exist and can be reached through impartial analysis, scientific reasoning and expert knowledge" (Bertsou & Caramani, 2020, p. 4). This points to a technical committee at ISO which is dominated by experts, scientific discourse and impartial reflections. This is a challenging concept to measure. Thus, I operationalize technocratic legitimation as committee expertise using a broad set of indicators.

First, I rely on data from the World Bank data using two variables; "Research and development expenditure (as % of GDP)" and "Researchers in R&D (per million people)". The first variable expresses a country's expenditure on research and development (R&D) per year as a share of its GDP. The second variable measures the number of researchers expressed per million inhabitant. Researchers are defined as "professionals engaged in the conception or creation of new knowledge, products, processes, methods and systems, as well as in the management of the projects concerned" (OECD, 2015, p. 162), and thus includes persons from both public and private sector. Because of this broad definition, one need not hold a researcher title or a doctor's degree to be labeled a researcher, making the data match better with the idea of a committee expert in ISO. These two variables have time series that run from 2004 to 2021.

Second, I rely on data from the World Intellectual Property Organization (WIPO) for more fine-grained variables: "High tech exports as % of total trade", "University-industry R&D collaboration", "Scientific and technical articles/bn PPP$ GDP", "Gross domestic expenditure on research and development (GERD) performed by business, % GDP" and "Percentage knowledge-intensive employment". The variables proxy the degree of expertise in the given countries. Many of the measures are particularly focused on the industry sector because most experts in TCs come from industry. However, WIPO data has shorter time series, beginning in 2013.

Using these variables, committee expertise is calculated as the year-wise average over all countries with P-membership in the given committee. Thus, for example, committees with a high proportion of R&D-intensive countries will have a higher value on the "Research and development expenditure (as % of GDP)" variable. Table B.6 shows descriptive statistics for the variables.

One drawback with relying on World Bank and WIPO data, in contrast to generating the variables from the dataset itself as done in section B.0.2, is that the coverage is

smaller compared to the original dataset. Out of 2116 country-years, only 1295 have data on R&D expenses and 1071 have data on researchers. For the high-tech exports, R&D collaboration and articles published, the number of country-years covered are 998. The number is 781 for business GERD and 899 for knowledge-intensive employment. This means that some countries will not be used in the calculation of committee expertise, even though they were P-members in that committee. The selection of countries is likely biased towards industrialized nations with efficient bureaucracies, as these countries are better equipped to provide data to international organizations. This tendency may correlate with higher expertise, potentially inflating the overall values. However, since the missing data is similar across committees and comparisons are made between committees, these missing data points should not bias the estimates of the models.

Table B.6: Descriptive statistics for committee expertise.

	Technocratic input legitimation						
	Coverage: 2004-2021		*Coverage: 2013-2021*				
	R&D % of GDP	Researchers per million people	High-tech exports, % total trade	University-industry R&D collaboration	Scientific and technical articles/ bn PPP$ GDP	GERD performed by business, % GDP	Knowledge-intensive employment, %
Mean	2.015	3706.014	39.000	59.223	43.143	36.200	61.834
Median	2.016	3656.027	37.583	59.685	43.576	36.736	62.017
Max	4.930	9081.936	100.000	72.900	64.036	84.900	82.888
Min	0.322	600.191	7.400	37.600	11.900	3.000	28.494

B.0.4 Measuring democratic and technocratic output legitimation: Dictionary methods

Output legitimation is measured by estimating the use of democratic and technocratic legitimation rhetoric or legitimation statements when ISO writes about their standards on their webpage. There are two types of measurements; coding of individual sentences (described in Section B.0.5) and use of dictionaries (described here, in Section B.0.4).

Dictionary approaches are common and intuitive methods of classifying text (Grimmer et al., 2022). The dictionary contains terms that are assumed to be indicators of an underlying theoretical concepts – here being technocratic and democratic legitimation respectively. To construct these dictionaries, I draw inspiration from measurements of legitimation strategies performed by Schmidtke et al. (2023), where they describe the concepts and list som keywords for democratic and technocratic legitimation respectively, which guide my dictionary measures. All the dictionaries are summarized in Table B.7.

Democratic legitimation rhetoric emphasizes democracy, human rights and the rule of law (Schmidtke et al., 2023, p. 90). Keywords in a dictionary that measures democratic legitimation would encompass terms such as: democracy, cooperation with citizens/civil society, democratic institutions, inclusion/involvement of stakeholders/people/civil society, popular participation, inclusion of non-state actors, participation, engagement, transparency, accountability, inclusivity, equity, equality, democracy promotion, democratic empowerment, consolidation/promotion of democratic institutions/values, good governance and popular participation (see pages 13-14 in Appendix of Schmidtke et al. (2023)).

Using these keywords directly would produce a dictionary of less than 50 words, which is too small to capture meaningful variation. Therefore, to measure democratic legitimation, I collect two different dictionaries of larger sizes. First, I compile one dictionary from United Nations General Assembly (UNGA) speeches between 1990 and 2000 (Baturo et al., 2017). Countries have been found to be particularly apt to use democratic rhetoric in their UNGA speeches in this period (Hecht, 2016). More information on the UNGA Debates dictionary can be found in section B.0.4.1.

Second, I employ one pre-made dictionary including four different dimensions of Corporate Social Responsibility (CSR) terms made by Pencle and Mălăescu (2016). CSR has been found to be a strategy to achieve legitimation within appropriate contexts (Frynas & Stephens, 2015). More information on the CSR dictionary can be found in section B.0.4.2. This dictionary has been validated by expert-coders, and thus, overlapping findings between the two dictionaries would imply a valid measure of democratic legitimation strategies.

Technocratic legitimation rhetoric are related to expertise, problem-solving capacity and neutrality (Schmidtke et al., 2023, p. 90). Keywords indicating

technocratic legitimation include: objectivity, neutrality, (expert) knowledge, technical solutions, expertise, scientific, excellent professionals, high quality of staff, well-trained and dedicated personnel, skill, neutrality, membership enlargement, hard-working/committed staff, aims to integrate, objectivity, neutrality, expert knowledge, technical solutions, expertise, knowledge, scientific, excellent professionals, high quality of staff, well-trained and dedicated personnel, skill, capability, membership enlargement and hard-working/committed staff (see pages 24 and 27 in Appendix of Schmidtke et al. (2023)).

There are fewer existing methods to gauge technocratic legitimation, so in this case, I compile two dictionaries. Both dictionaries are based on sources that employ technocratic rhetoric, namely abstracts from research papers and patents. However, in contrast to the UNGA Debates, the purpose of these sources is more mixed, both justifying its content but also informing an audience. Using a pure word count on the complete sample would therefore capture texts that do not aim to justify and therefore fail to capture legitimation language. To account for this, I use a keyword approach and select texts that mention relevant technocratic legitimation terms, and then pick the most often occurring words to construct the dictionaries. For information on the technocratic legitimation dictionaries, see section B.0.4.3.

Dimension	**Source**	**Number of words**
UNGA speeches	UNGA	198
Labor	CSR	192
Environment	CSR	248
Human Rights	CSR	169
Social and Community	CSR	195
Research papers	Scopus	213
Patents	PatentsView	239

Table B.7: Overview of dictionary sources and sizes.

To estimate the degree of technocratic and democratic justification in the ISO news text, I match the stemmed words in the dictionary to stemmed words in the news text. ISO regularly publishes news on their webpage to inform and market new or existing standards. Per 2024, these news can be found here: https://www.iso.org/insights. The ISO news text were preprocessed by lowercasing, stemming and removing punctuation, symbols, numbers and stopwords. Because taking the stem of the word reduces it to its root form, this allows matching of different word inflections, e.g. so that *hope* and *hoping* both become *hop*.

After matching, I calculate, per text, the number of words that also occur in the

dictionaries, i.e. the technocratic or democratic legitimation words. Then I calculate the share of technocratic and democratic legitimation words in the news text compared to its total number of words. Taking the share accounts for the fact that some news texts are longer than others. Tables B.8 and B.9 show descriptive statistics for the measures on democratic and technocratic justification. The numbers for the dictionary methods are shares of overlapping words – for example, on average about 26 percent of the words in the ISO news text also occur in the UNGA Dictionary. For the legitimation statement columns, the numbers refer to the share of news' sentences that are coded as either democratic or technocratic legitimation statements. On average, 18 percent of the sentences are democratic legitimation statements and 44 percent are technocratic legitimation statements. 38 percent of the sentences are on average not legitimation statements.

Table B.8: Descriptive statistics for democratic output legitimation

	Democratic output legitimation					
	UNGA Dictionary	*CSR Dictionary*				*Legitimation statements*
	UNGA	**Human Rights**	**Labor**	**Environment**	**Community and Social**	**Democratic**
Mean	0.256	0.086	0.142	0.151	0.150	0.181
Median	0.261	0.081	0.134	0.154	0.144	0.125
Max	0.419	0.363	0.366	0.308	0.329	0.800
Min	0.053	0.008	0.017	0.014	0.019	0.000

Table B.9: Descriptive statistics for technocratic output legitimation

	Technocratic output legitimation		
	Research Paper Dictionary	*Patent Dictionary*	*Legitimation Statements*
Mean	0.268	0.239	0.442
Median	0.268	0.232	0.438
Max	0.689	0.672	1.000
Min	0.076	0.080	0.000

B.0.4.1 United Nations General Assembly (UNGA) speeches

For the first dictionary measuring democratic rhetoric, I use UN General Assembly speeches as a reference. The speeches are gathered from Baturo et al. (2017). While UNGA speeches are known for their democratic rhetoric in general, they have been found to be particularly democratically oriented in the time period between 1990 and 2000, and I thus base the dictionary in this time period (Hecht, 2016). The dictionary was constructed by picking the most common words used in this time period. I first preprocess the text by removing numbers, punctuation and stopwords, taking the stem of the words, and then manually remove words that represent other aspects of the conversations beyond democratic rhetoric, including organizational procedures, such as "secretary" and "sixth", and geographical words such as "sudan" and "western". Last, I count the number of occurrences for each word and choose the words occurring at least 2000 times. While the results are robust to other cutoffs (see Table B.10), a cutoff of 2000 produces a dictionary of roughly similar size as the CSR dictionaries.

Overall, the procedure creates a dictionary of 198 words. The contents of the dictionary are listed in Table B.11.

Table B.10: Democratic output legitimation and social standards using different cutoffs for UNGA Dictionary.

	Percent democratic legitimation words		
	Cutoff 1000	Cutoff 1500	Cutoff 2500
Societal	0.033**	0.035**	0.021*
	0.011	0.010	0.009
Num.Obs.	1505	1505	1505
R2	0.718	0.711	0.695
R2 Adj.	0.668	0.660	0.641

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Fixed effects: Year and committee
Clustered standard errors by committee and year
Coverage: 1999 - 2022

Table B.11: List of words in UNGA Debates dictionary.

UNGA Debates 1	UNGA Debates 2	UNGA Debates 3	UNGA Debates 4	UNGA Debates 5	UNGA Debates 6
nation	unit	countri	develop	peac	world
secur	peopl	econom	organ	human	region
communiti	govern	effort	right	support	cooper
assembl	polit	continu	conflict	time	process
global	social	hope	effect	achiev	war
presid	republ	commit	confer	establish	situat
respect	relat	issu	resolut	respons	reform
principl	democrat	concern	contribut	forc	role
action	implement	recent	activ	system	increas
agreement	weapon	nuclear	call	progress	democraci
futur	challeng	assist	ensur	promot	strengthen
solut	resourc	elect	remain	success	negoti
trade	opportun	posit	programm	stabil	major
meet	result	live	includ	economi	initi
view	express	law	particip	parti	polici
adopt	environ	measur	provid	special	financi
integr	arm	institut	prevent	peacekeep	repres
requir	question	power	centuri	deleg	oper
treati	convent	poverti	protect	regard	decis
mean	territori	crisi	univers	sustain	level
agenda	propos	base	europ	creat	past
address	object	independ	summit	import	chang
freedom	step	common	societi	bring	declar
condit	foreign	dialogu	settlement	play	comprehens
exist	basi	act	militari	threat	free
disarma	central	popul	middl	equal	natur
encourag	constitut	held	aim	justic	lead
context	suffer	set	sign	improv	resolv
share	island	determin	life	fundament	direct
build	union	histori	framework	growth	task
product	destruct	humanitarian	involv	cultur	goal
structur	debt	children	experi	accept	emerg
report	signific	current	take	confid	reflect

B.0.4.2 Corporate Social Responsibility dictionary (CSR)

The Corporate Social Responsibility (CSR) dictionary is gathered from Pencle and Mălăescu (2016). Relying on relevant literature, the authors denote four different dimensions in which CSR varies Pencle and Mălăescu (2016, p. 112):

- **Human Rights Dimension:** Considers the organization's involvement, stance, and impact on activities related to individual and collective human rights of all stakeholders including minorities and underrepresented groups, and strives for inclusiveness.
- **Employee Dimension:** Considers the organization's involvement, stance, and impact on activities related to its internal stakeholders, including employees and other forms of human resources.
- **Environment Dimension:** Considers the organization's involvement, stance, and impact on activities related to the environment and natural resources such as water, energy, waste, pollution, bio diversity, natural gasses, and material stewardship in general.
- **Social and Community Dimension:** Considers the organization's involvement, stance, and impact on activities related to social issues such as local community, indigenous people, and societal development.

The dictionary is composed through inductive approaches, in which the dimensions were denoted through literature research, and deductive approaches, in which the words related to CSR were gathered from research papers on CSR and companies' websites. The dictionary was then validated by experts.

Some of the dictionary words are bigrams. Because the news are coded as unigrams, this would complicate the matching of words, and thus these bigrams were excluded. Because the birgams usually contained a similar unigram word (for example the unigram "aboriginal" and the bigram "aboriginal rights"), this is unlikely to influence the results significantly. Tables B.12, B.13, B.14 and B.15 list the different words within each dimension of the CSR dictionary.

Table B.12: List of words in CSR Human Rights dictionary.

Human Rights 1	Human Rights 2	Human Rights 3	Human Rights 4	Human Rights 5	Human Rights 6
aborigin	abus	accept	accommod	account	activ
act	adopt	advers	african	age	agent
agreement	aid	avoid	award	awar	balanc
baselin	belong	benefici	beneficiari	benefit	bylaw
care	certif	certifi	charit	civil	claim
class	coach	commit	committe	communiti	constitut
core	coven	cultur	custodian	develop	die
disabl	disadvantag	disast	discrimin	discriminatori	divers
diversif	diversifi	duti	educ	elect	employ
employe	empow	empower	enabl	engag	enhanc
equal	equiti	ergonom	ethic	ethnic	exercis
eye	face	fair	famili	femal	fiduciari
free	freedom	gay	gender	govern	habitat
hazard	healthcar	hire	honest	honesti	humanitarian
human	hungri	imprison	inclus	infring	interest
involuntarili	involuntari	involv	labor	law	legal
lesbian	lifestyl	mate	medicaid	medicar	medicin
minor	mission	nation	nativ	outsid	outsourc
ownership	parti	partner	partnership	payrol	peer
pension	peopl	perform	person	personnel	philanthropi
philosophi	plural	poor	prejud	prejudic	preserv
privileg	protect	race	racial	rape	realloc
rebuild	recognit	regul	regulatori	relat	relationship
religi	reserv	retir	right	safeti	salari
scholarship	sexual	sick	social	spous	strength
talent	teamwork	unbias	uncondit	unemploy	uneth
unfair	union	unlaw	vote	vulner	well
wheelchair	women	workday	worker	workforc	workplac
workspac					

Table B.13: List of words in CSR Labor dictionary.

Labor 1	Labor 2	Labor 3	Labor 4	Labor 5	Labor 6
abus	accommod	account	age	alcohol	balanc
bathroom	believ	benefici	beneficiari	benefit	bodi
bonus	boundari	bylaw	care	certif	certifi
civil	claim	class	contribut	cultur	custodian
custom	develop	die	director	disabl	discrimin
discriminatori	divers	diversif	diversifi	drug	educ
elect	employ	employe	empow	empower	enabl
engag	enhanc	enjoy	environ	equal	equiti
ergonom	ethic	ethnic	even	exercis	experi
experienc	fair	famili	femal	fiduciari	freedom
gay	goal	govern	health	healthcar	healthi
hire	humanitarian	human	incent	individu	infring
insur	involv	job	knowledg	knowledgebas	labor
law	leader	leadership	learn	legal	lesbian
lifestyl	live	manag	mate	meal	medicaid
medicar	medicin	minor	mission	moral	mortal
multin	nativ	nonemploye	nonrenew	occup	offic
outsourc	paid	particip	participatori	parti	partner
payrol	peer	pension	peopl	perform	person
personnel	philosophi	posit	practic	prejud	prescrib
principl	privileg	product	profession	promot	protect
qualiti	race	rape	rate	realloc	recognit
recogn	regul	regulatori	reimburs	relat	relationship
religi	respect	respons	retir	right	role
safe	safeti	salari	satisfact	scholarship	season
select	sensit	serv	servic	sexual	sick
size	social	spous	stakehold	strength	suitabl
sustain	talent	team	teamwork	tenur	train
trust	truth	understand	undocu	unemploy	uneth
unfair	union	unproduct	unsaf	wage	wear
welfar	well	wheelchair	wife	women	work
workday	worker	workforc	workmen	workplac	workspac

Table B.14: List of words in CSR Environment dictionary.

Environment 1	Environment 2	Environment 3	Environment 4	Environment 5	Environment 6
abus	accept	accommod	account	activ	adopt
advers	affluenc	agreement	agricultur	agro	aid
amazon	anim	anti	arm	assur	attent
attribut	audit	auditor	authent	awar	balanc
barg	baselin	basin	beauti	benefici	beneficiari
benefit	biodivers	board	bodi	boundari	bribe
broad	bromid	bromin	build	bull	burn
bylaw	cage	carbon	catastroph	chemic	chlorid
chlorin	citi	civil	climat	co2	code
conserv	conservationist	corn	corpor	counti	countri
coven	crop	crud	cultiv	custodian	custom
cycl	deleg	demograph	deplet	design	dioxid
disclos	disclosur	dispos	divers	diversif	diversifi
dwindl	easement	ecolog	educ	effici	emiss
employ	enhanc	environ	environment	environmentalist	epa
equip	esg	ethic	evolut	exit	expand
facil	fair	farm	farmer	farmland	flammabl
fli	foodservic	fossil	free	freedom	fundrais
fund	gold	gri	groundwat	grove	grow
guidelin	harm	harmoni	hazard	hcfc	humanitarian
human	hungri	hybrid	iirc	impair	implement
improv	incent	indemnif	independ	indic	infring
innov	iso	kld	live	local	mainten
map	materi	meaning	member	migrat	msci
natur	nuclear	organ	overcapac	oxid	ozon
petroleum	pipelin	plant	pollut	power	practic
preserv	prevent	purif	qualiti	rainforest	reason
rebuild	recover	reduc	regul	renew	requir
research	reserv	reservoir	respect	respons	reusabl
reus	right	river	royalti	safe	safeti
saltwat	scienc	scientif	scientist	season	seed
select	sensit	shipyard	shore	shrink	site
solar	solubl	solvent	sourc	stakehold	stewardship
suitabl	sulfur	survey	sustain	symbiot	target
technolog	terrorist	threat	tornado	tradeoff	transpar
tree	truth	turbin	unavoid	unbias	underutil
uneconom	uneth	unfair	unproduct	unprofit	unrestrict
unsaf	unus	uproot	urban	veget	volcan
voluntarili	voluntari	vulner	warm	wast	wasteland
water	wave	weather	wetland	wilder	wind
windmil	wood	world	wrongdo	wrong	yard
yield	zone				

Table B.15: List of words in CSR Social and Community dictionary.

Social & Comm. 1	Social & Comm. 2	Social & Comm. 3	Social & Comm. 4	Social & Comm. 5	Social & Comm. 6
abus	accept	accommod	accompani	account	activ
adopt	afford	age	aid	american	arm
benefici	beneficiari	benefit	bribe	build	certif
certifi	charit	chariti	civic	civil	class
clean	cleaner	cleanli	cleanup	collect	commit
common	communal	communiti	concern	contribut	countri
counti	csr	cultur	custodian	deleg	demograph
develop	diet	disabl	disclosur	divers	diversif
diversifi	drink	educ	elect	employ	empow
empower	enabl	engag	equal	ethic	fair
famili	femal	foodbank	freedom	fund	fundrais
futur	give	govern	habitat	healthcar	help
hope	human	humanitarian	hungri	improv	indigen
innov	intellig	involv	jeopard	labor	law
lead	leadership	learn	legal	lifestyl	live
local	meaning	medicaid	medicar	medicin	minim
minor	mission	moral	mortal	multin	nativ
natur	open	orphan	outperform	outsourc	ownership
own	particip	parti	partner	partnership	peopl
perform	person	philanthrop	philanthropi	philosophi	plan
plural	poor	prejud	prejudic	preserv	prevent
principl	privileg	project	protect	public	race
rape	rebuild	recognit	recogn	recoveri	redeem
reduc	regul	regulatori	relat	relationship	reliabl
religi	reli	renew	renov	respect	respons
role	safe	safeti	scholarship	servic	sick
social	societ	sponsor	sponsorship	stakehold	sustain
talent	team	train	transpar	trust	truste
truth	uncondit	unemploy	uneth	unfair	unfriend
union	unit	unrestrict	unsaf	uproot	urban
voluntarili	voluntari	volunt	volunteer	vote	vulner
water	well	women	work	world	wrongdoer
wrongdo	wrong	zone			

B.0.4.3 Technocratic legitimation dictionaries

The two dictionaries measuring technocratic legitimation are based on abstracts from research papers and patents respectively. There are two steps in constructing the sample pertaining to each of these dictionaries. First, I collect the base data. Abstracts on research papers are gathered from the Scopus database. The number of research papers in the Scopus database is very large, so I pick the 1000 most cited papers per year between 2004 and 2022 for each possible research field. For patent abstracts, I use the *patentsview* package (Toole et al., 2021), which is based on UPSTO patent data (US Patent and Trademark Office), also here picking abstracts between 2004 and 2022 for all technical fields.

The second step of constructing the baseline sample involved filtering out abstracts that would be likely to contain words relevant to measuring technocratic legitimation. These texts are chosen based on key terms, which are again based on measurements by Schmidtke et al. (2023) (see section B.0.4). The filtering terms are: "scientific, technical, professional, neutral, knowledge, quality, innovation, solution, solve, efficient, efficiency, compatible, compatibility, effective, coordinate, coordination, streamline, strategic, systematic, optimize, optimal, optimization, cost-effective, cost-efficient, quality, performance, expert, experts, expertise, functional". Only abstracts containing one or more of these words are further used to produce the dictionaries.

These two processing steps produced one dictionary based on research paper abstracts with roughly 46,000 words, and one dictionary based on patent abstracts with roughly 234,000 words. The next step thus involved shortening these dictionaries to only the most relevant words. I do this by selecting the top most common words across the abstracts. As with the UNGA Debates dictionary, this required a cutoff of how many times a word ought to occur to be included into the dictionary. Here, I pick a cutoff which leads the sizes of the technocratic legitimation dictionaries to match the sizes of the democratic legitimation dictionaries (an overview of the dictionary sizes can be found in Table B.7). For the research paper dictionary, I thus selected words that occurred 500 times or more, and for the patents dictionary, the words had to occur 15,000 times or more.

The measures are rather sensitive to this cutoff choice, as shown in Table B.16. The research paper dictionary, although already being insignificant, also changes sign upon varying the cutoff. The patents dictionary generates a consistently positive coefficient, but loses its size and significance when high cutoffs are chosen.

A list of the words compiled in each dictionary can be found in Table B.17 for words present in the research paper dictionary, and Table B.18 for the words present in the patent dictionary.

Table B.16: Technocratic output legitimation and physical standards using different cutoffs for the dictionaries.

	Percent technocratic legitimation words							
	Cutoff: 200 / 10000		Cutoff: 400 / 12000		Cutoff: 800 / 20000		Cutoff: 1200 / 25000	
	Res.	Pat.	Res.	Pat.	Res.	Pat.	Res.	Pat.
Physical	−0.015	0.015*	−0.005	0.014+	0.002	0.007	0.002	0.003
	0.012	0.006	0.009	0.007	0.006	0.006	0.005	0.004
Num. Obs.	1505	1505	1505	1505	1505	1505	1504	1505
R2	0.735	0.708	0.699	0.700	0.716	0.668	0.718	0.675
2 Adj.	0.688	0.656	0.646	0.647	0.666	0.610	0.668	0.618

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Fixed effects: Year and committee

Clustered standard errors by committee and year

Coverage: 1999 - 2022

Table B.17: List of words in Research Papers dictionary.

Research papers 1	Research papers 2	Research papers 3	Research papers 4	Research papers 5	Research papers 6
perform	function	effect	effici	studi	review
develop	qualiti	data	model	method	research
optim	knowledg	improv	system	result	solut
process	systemat	includ	materi	provid	applic
base	cell	structur	measur	energi	activ
approach	innov	increas	scientif	design	product
paper	analysi	technolog	inform	control	discuss
organ	properti	algorithm	potenti	report	requir
compar	health	evalu	recent	current	practic
set	relat	manag	assess	imag	propos
identifi	literatur	network	resolut	signific	evid
test	factor	mechan	time	strategi	specif
understand	achiev	devic	challeng	firm	clinic
oper	demonstr	estim	treatment	techniqu	human
suggest	power	reduc	comput	level	diseas
limit	field	addit	select	environment	surfac
rang	combin	enhanc	integr	low	water
futur	articl	theori	generat	expert	electron
respons	support	relationship	advanc	determin	predict
coeffici	direct	key	investig	paramet	interact
solar	type	focus	framework	physic	cost
recommend	profession	implement	rate	chemic	major
conduct	global	object	complex	coordin	examin
technic	learn	posit	role	sampl	impact
patient	risk	densiti	social	region	wide
metal	communiti	lead	standard	exist	tool
individu	outcom	graphen	scale	condit	form
appli	aim	produc	sustain	issu	biolog
influenc	natur	size	chang	observ	oxid
describ	contribut	enabl	sourc	sequenc	high
industri	compon	public	gene	care	correl
obtain	search	term	address	consist	featur
target	composit	solv	drug	simul	find
emerg	critic	due	valid	affect	spatial
multipl	experi	reaction	variabl	genom	stabil
statist	dynam	found			

Table B.18: List of words in Patents dictionary.

Patents 1	Patents 2	Patents 3	Patents 4	Patents 5	Patents 6
method	includ	system	perform	devic	data
provid	solut	function	imag	effici	compris
base	process	effect	control	signal	invent
determin	qualiti	optim	form	inform	unit
oper	layer	generat	improv	receiv	plural
network	composit	coeffici	coordin	materi	configur
select	surfac	relat	set	apparatus	user
communic	solvent	time	posit	power	measur
compon	obtain	reduc	compound	display	element
andor	comput	light	resolut	detect	acid
structur	substrat	portion	applic	embodi	step
product	amount	circuit	cell	disclos	connect
metal	output	direct	object	optic	modul
produc	paramet	increas	channel	input	polym
activ	calcul	servic	temperatur	result	organ
region	transmiss	liquid	heat	agent	water
transmit	target	locat	film	sourc	current
storag	filter	identifi	electrod	electr	level
memori	block	model	combin	appli	capabl
thereof	condit	content	weight	addit	respons
store	access	sensor	frequenc	repres	low
adjust	code	flow	manag	termin	test
particl	resourc	indic	rang	aqueous	coat
node	enhanc	prepar	vehicl	respect	separ
voltag	video	contact	valu	sampl	request
wireless	rate	enabl	remov	resin	pattern
support	multipl	frame	gas	refer	design
specif	pixel	neutral	execut	mobil	characterist
phase	requir	electron	monitor	subject	predetermin
processor	color	mode	type	oxid	compat
mixtur	station	util	line	prevent	drive
extract	bodi	suppli	interfac	carbon	resist
reaction	treatment	record	energi	manufactur	switch
fluid	transform	correct	program	achiev	pressur
estim	server	field	section	engin	distribut
semiconductor	arrang	chang	stream	lower	path
salt	techniqu	formula	coupl	mean	implement
transfer	conduct	treat	space	integr	encod
defin	thermal	messag	size	adapt	convert
print	mechan	packet	featur	catalyst	

B.0.5 Measuring democratic and technocratic output legitimation: Legitimation statement method

The other method of measuring output legitimation used here is to perform individual coding of each sentence. This measure follows the measurement approach of Schmidtke et al. (2023). In their dataset on the legitimation strategies of IOs, they base measures on IOs' textual data, such as annual reports and meeting communiqués, and perform manual coding on each paragraph in these texts. For each paragraph, coders were asked to first determine whether the paragraph contained a legitimation statement and, if so, code a variety of characteristics to that legitimation statement.

The ISO news pieces are concise, so I divided them into sentences rather than paragraphs, resulting in roughly 38,500 sentences from 1,500 articles. The definition of a legitimation statement follows Schmidtke et al. (2023), with democratic and technocratic strategies summarized from their Appendix. To make the coding feasible with the given resources, I use GPT-3.

> You are a political scientist and expert on legitimacy and legitimation. Your task is to code sentences that discuss the contribution of international standards.
> First, consider whether the sentence is a legitimation statement. This is a proposition legitimizing a standard based on an evaluative argument. For example: 'This standard can provide enormous benefits to society'.
> Second, if the sentence is a legitimation statement, code whether this is a technocratic or a democratic legitimation statement.
> Democratic legitimation statements justify a standard by alluding to popular democracy, representation, participation, transparency, accountability, engagement, equity, equality, democratic empowerment, non-discrimination, human rights, liberty, freedom, economic rights, environmental protection, green economy, agricultural development, sustainability or climate change.
> Technocratic legitimation statements justify a standard by alluding to objectivity, neutrality, expert knowledge, technical solutions, expertise, science, excellent professionals, high quality of staff, well-trained and dedicated personnel, skill, neutrality, hard-working/committed staff, quality of output, innovation, efficiency or optimization.
> The sentence reads: X
> What kind of legitimation statement is this? Pick one of the following:
> (0) no legitimation statement, (1) democratic legitimation statement, (2) technocratic legitimation statement

Coded examples of technocratic legitimation statements:

- "that makes international standards a useful resource when developing regulations, and gives regulators the benefit of the consolidated opinion of experts without having to call on their services directly."
- "taking advantage of the very latest technology in crop protection and nutrition, using water more sustainably, and basing agronomic plans on hard data, sounds like a formula for success."
- "we strive to hire, train and retain the best possible talent from around the world."
- "implementing these standards should simplify the exchange of information between stakeholders and enhance the interoperability of systems in the medical field."

Coded examples of democratic legitimation statements:

- "as the technology works itself into almost every aspect of our lives, ai will need protecting against negative uses, both deliberate and unintended, for the sake of individual rights, human safety and societal welfare."
- "this means engaging stakeholders and listening to their perceptions, but also explaining the trade-offs, because there are very many trade-offs in this transition."
- "consequently, the published standards are designed to be applicable to all organizations, regardless of size, industry sector, geographical location or political persuasion."
- "and the value that is added is not necessarily financial, it can also be social or environmental, for example," she says."

To validate the coding, I code 1000 randomly chosen sentences manually. Overall, there is an 80 percent overlap between my coding and the GPT-3 coding. Among the democratic legitimation statements, the overlap is 66 percent and for the technocratic statement, it is 70 percent. The main differences come from a more lenient interpretation of legitimation statement by GPT-3. GPT-3 interprets more general parts of the text as legitimation statements, e.g. the sentence "however, to have any sort of beneficial impact, it is vital that iso's ghg standards are successfully implemented worldwide". While this sentence does highlight the environmental benefits of the standard, the main focus is that the standard needs to be spread before it can have an impact. I coded this sentence as no legitimation statement, while GPT-3 coded it to be a democratic legitimation statement.

For the technocratic legitimation strategy, the legitimation statements are easier to

identify, but also here, GPT-3 is more lenient. For example, it codes presentations of standards as legitimation statements, such as "international standard iso 20252:2019, market, opinion and social research, including insights and data analytics – vocabulary and service requirements, sets out guidance and requirements relating to the way in which market research studies are planned, carried out, supervised, and reported to clients commissioning such projects". While this increases the number of legitimation statements identified in the text, the ratio between democratic and technocratic legitimation statements are similar between the GPT-coded and the manually coded content: 15.7 percent manually coded democratic to 18.5 percent GPT-3 coded democratic, 32.7 percent manually coded technocratic to 39 percent GPT-coded technocratic, and 51.6 manually coded to not be legitimation statements to 42.5 GPT-coded sentences to not be legitimation statements.

Figure B.2 shows the distribution of the roughly 38,500 sentences for the GPT-coding. Indeed, most of the sentences contained no legitimation statement. Yet, sentences containing technocratic legitimation statements were also common. Only 18.5 percent of the sentences contained democratic legitimation statements, despite more articles mentioning societal standards (992) compared to physical standards (514). This shows how ISO is a functional organization first and foremost, which builds its discourse on rational and expert-driven rhetoric, as discussed in Section II.5.

In the models, I aggregate the data up to the level of news by estimating the share of sentences for each news article that contain democratic and technocratic legitimation statements respectively. Figure B.3 shows this difference over time.

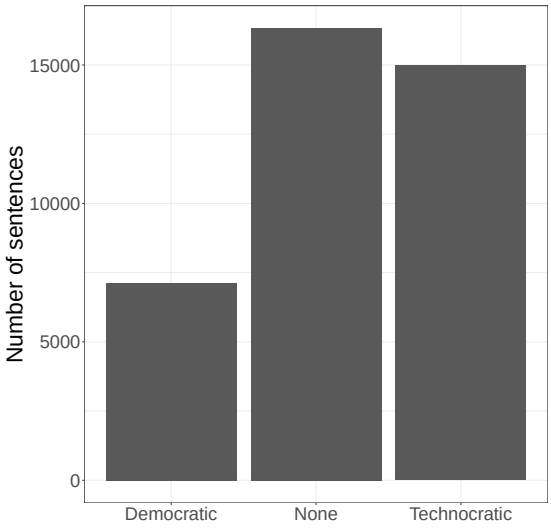

Figure B.2: Number of sentences containing various legitimation statements.

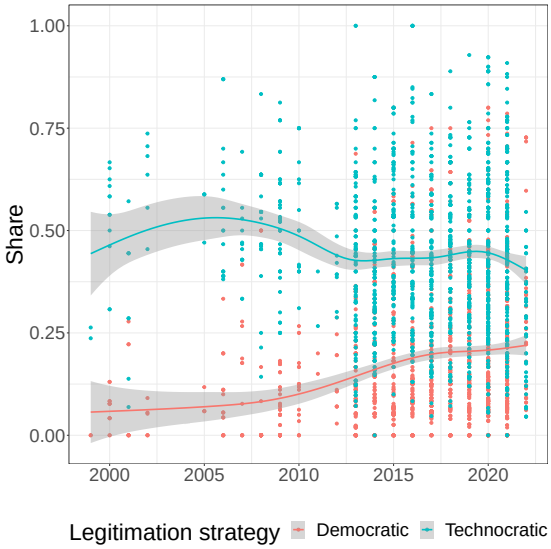

Figure B.3: Share of democratic and technocratic legitimation statements in news articles from 1999 to 2022.

Figure B.4: Descriptive overview of legitimation statements.

B.0.6 Detailed tables for Figure II.3

This section expands on the models behind the coefficient plot in Figure II.3. In contrast to the coefficient plot, the coefficients in the models below are not standardized.

B.0.6.1 Democratic and technocratic input legitimation models

In the input models, the sample includes all national member bodies participating in technical committees (TCs) and subcommittees (SCs) from 2004 to 2022, and committee is the unit of analysis. The independent variables are the committee diversity (as described in Section B.0.2) for the democratic models and committee expertise (as described in section B.0.3) for the technocratic models.

Models for the democratic input legitimation coefficients can be found in Table B.19 (with number of societal standards as dependent variable) and B.20 (with number of physical standards as dependent variable). For technocratic legitimation, the models are shown in Table B.21 (with number of physical standards as dependent variable) and B.22 (with number of societal standards as dependent variable).

The dependent variable is the number of societal or physical standards produced in the TC at any given year. On average, there are notably fewer societal standards produced in each committee per year than physical ones; 2 societal standards compared to 46 physical standards. All models employ fixed effects by committee and year, and likewise cluster standard errors by committee year.

Table B.19: Democratic input legitimation and societal standards.

	Number of societal standards produced in technical committee			
	Region		Sector	
	Rae Index	Shannon H	Rae Index	Shannon H
Committee diversity	2.150+	2.193*	4.242*	11.413*
	1.062	0.932	1.590	4.537
Num. Obs.	12 228	11 778	8839	8667
R2	0.696	0.701	0.706	0.714
R2 Adj.	0.676	0.681	0.685	0.693

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001
Fixed effects: Year and committee
Clustered standard errors by committee and year
Coverage: 2004 - 2022

Table B.20: Democratic input legitimation and physical standards.

	Number of physical standards produced in technical committee			
	Region		Sector	
	Rae Index	Shannon H	Rae Index	Shannon H
Committee diversity	−19.483*	−17.317	10.307	25.837
	9.085	10.055	9.100	21.413
Num. Obs.	12 228	11 778	8839	8667
R2	0.899	0.900	0.898	0.898
R2 Adj.	0.893	0.893	0.891	0.891

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001
Fixed effects: Year and committee
Clustered standard errors by committee and year
Coverage: 2004 - 2022

Table B.21: Technocratic input legitimation and physical standards.

	Number of physical standards produced in technical committee						
	R&D % of GDP	Researchers	High-tech exports	University-industry R&D collaboration	Scientific and technical articles	BERD	Knowledge-intensive employment
Committee expertise	−0.200	0.009*	0.060	0.345	0.257+	0.363*	0.217
	5.704	0.003	0.146	0.211	0.137	0.127	0.180
Num.Obs.	11 516	11 511	6136	6136	6136	6134	6136
R2	0.902	0.903	0.979	0.979	0.979	0.979	0.979
R2 Adj.	0.896	0.896	0.977	0.977	0.977	0.977	0.977

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001

Fixed effects: Committee and year

Clustered standard errors by committee and year

Coverage: 2004 - 2021

Table B.22: Technocratic output legitimation and societal standards.

	Number of societal standards produced in technical committee						
	R&D % of GDP	Researchers	High-tech exports	University-industry R&D collaboration	Scientific and technical articles	BERD	Knowledge-intensive employment
Committee expertise	−5.467**	−0.001*	−0.112*	−0.161*	−0.029	−0.058	−0.087+
	1.679	0.001	0.040	0.068	0.043	0.040	0.042
Num.Obs.	11 516	11 511	6136	6136	6136	6134	6136
R2	0.701	0.698	0.912	0.912	0.911	0.911	0.912
R2 Adj.	0.680	0.677	0.900	0.900	0.899	0.899	0.900

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001

Fixed effects: Committee and year

Clustered standard errors by committee and year

Coverage: 2004 - 2021

Democratic and technocratic output legitimation models

In the output models of Figure II.3, the dependent variable is the average share of words in a news article mentioning a given standard that also occur in the relevant dictionary, as described in Section B.0.4. The sample includes all news articles that mention a standard which could be identified as either societal or physical. The independent variable is thus whether the standard mentioned in the news article was classified as societal or physical. About 1500 unique standards were mentioned in at least one article. Of these standards, 992 were classified as social and 514 as physical.

The models estimating coefficients for democratic output legitimation can be found in Table B.23 for societal standards and B.24 for physical standards. Models for technocratic output legitimation for both physical and societal standards are in Table B.25.

In all models, standards occurring in news articles are the unit of analysis. A standard may be mentioned in several articles over the years and can thus occur multiple times. Due to the span of available data on ISO news, the time series runs from 1999 to 2022. To account for year-wise variation in which news articles that are published, and variation within committees such as specific jargon, the model employs year and committee fixed effects. Standard errors are likewise clustered by committee and year.

Table B.23: Democratic output legitimation and societal standards.

	Percent democratic legitimation words/statements					
	UNGA Debates	Human Rights CSR	Labor CSR	Environment CSR	Social and Community CSR	Legitimation Statements
Societal	0.028**	0.011***	0.022**	0.016+	0.021**	0.051+
	0.010	0.002	0.006	0.008	0.007	0.025
Num.Obs.	1505	1470	1505	1505	1505	1504
R2	0.694	0.708	0.786	0.754	0.743	0.479
R2 Adj.	0.640	0.655	0.748	0.711	0.698	0.387

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001
Fixed effects: Year and committee
Clustered standard errors by committee and year
Coverage: 1999 - 2022

Table B.24: Democratic output legitimation and physical standards.

	Percent democratic legitimation words/statements					
	UNGA Debates	Human Rights CSR	Labor CSR	Environment CSR	Social and Community CSR	Legitimation Statements
Physical	−0.028**	−0.011***	−0.022**	−0.016+	−0.021**	−0.051+
	0.010	0.002	0.006	0.008	0.007	0.025
Num.Obs.	1505	1470	1505	1505	1505	1504
R2	0.694	0.708	0.786	0.754	0.743	0.479
R2 Adj.	0.640	0.655	0.748	0.711	0.698	0.387

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001
Fixed effects: Year and committee
Clustered standard errors by committee and year
Coverage: 1999 - 2022

Table B.25: Technocratic output legitimation and physical/societal standards.

	Percent technocratic legitimation words/statements					
	Research papers	Patents	Legitimation Statements	Research papers	Patents	Legitimation Statements
Physical	−0.002	0.015*	0.069*			
	0.009	0.007	0.028			
Societal				0.002	−0.015*	−0.069*
				0.009	0.007	0.028
Num.Obs.	1505	1505	1505	1505	1505	1505
R2	0.698	0.691	0.417	0.698	0.691	0.417
R2 Adj.	0.645	0.636	0.313	0.645	0.636	0.313

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Fixed effects: Year and committee

Clustered standard errors by committee and year

Coverage: 1999 - 2022

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Appendix C

Appendix for Geopolitics in International Standardization Negotiations

C.0.1 Producing the datasets

Data on patents

To match technology areas of the standard ICS code to the patent IPC code, I used a concordance table from Blind (2004). The table is available at the StanDat webpage.

The concordance table produces the following technology areas: Health Care Technology, Environmental/Health Protection; Safety, Metrology and Measurement; Testing, Mechanical Systems, Fluid Systems, Mechanical Engineering, Energy; Heat Transfer Engineering, Electrical Engineering, Electronics, Telecommunications, Information Technology; Office Equipment, Image Technology, Precision Mechanics; Jewelry, Road Vehicle Engineering, Railway Engineering, Shipbuilding; Marine Structures, Aircraft; Space Vehicle Engineering, Materials Handling Equipment, Packaging; Distribution of Goods, Textile and Leather Technology, Clothing Industry, Agriculture, Food Technology, Chemical Technology, Mining; Minerals, Petroleum; Related Technology, Metallurgy, Wood Technology, Glass/Ceramics Industries, Rubber/Plastics Industries, Paper Technology, Paint/Color Industries, Construction Materials; Building, Civil Engineering, Military Engineering, Housekeeping; Entertainment; Sports.

- **Patent-Standard correspondence:** This proxies domestic relevance of an international standards. Estimated by finding the cosine similarity between abstracts of domestic patents in *t-1* and abstracts of international standards in *t* for every country in the sample. Before estimating the cosine similarity, the abstracts are pre-processed by removing punctuation, numbers and stop-words. Subsequently, the average cosine is aggregated up to country-year by taking the average cosine similarity between patents and standards in the given year.
- **GPT index:** Data for index based on the *patentsview* package, Toole et al. (2021), which is based on UPSTO patent data (US Patent and Trademark Office). Counts number of patent applications from each country, along with several

metadata fields such as citations and the patents' CPSC fields.

- **GPT classification:** Coded based on various literary sources mentioning examples of GPT technology.
- **Patents per resident:** Number of patent applications from the UPSTO dataset divided by total population, gathered from World Development Indicators through the World Economics and Politics Dataverse, i.e Graham and Tucker (2019) and Graham et al. (2018).
- **Democracy:** Based on the Electoral democracy index, i.e. the *v2x_polyarchy* variable from the Varieties of Democracy dataset, i.e. Coppedge et al. (2024).
- **GDP growth:** GNI growth gathered from World Development Indicators through the World Economics and Politics Dataverse, i.e Graham and Tucker (2019) and Graham et al. (2018).
- **Scientific and technical journal articles:** The number of scientific and engineering articles published in the following fields: physics, biology, chemistry, mathematics, clinical medicine, biomedical research, engineering and technology, and earth and space sciences. Data from World Development Indicators through the World Economics and Politics Dataverse, i.e. Graham and Tucker (2019) and Graham et al. (2018).
- **Technicians in R&D (per million people):** The number of technicians participated in Research & Development (R&D), expressed as per million. Technicians and equivalent staff are people who perform scientific and technical tasks involving the application of concepts and operational methods, normally under the supervision of researchers. Data gathered from World Development Indicators through the World Economics and Politics Dataverse, i.e. Graham and Tucker (2019) and Graham et al. (2018).

C.0.2 Index of GPT-ness

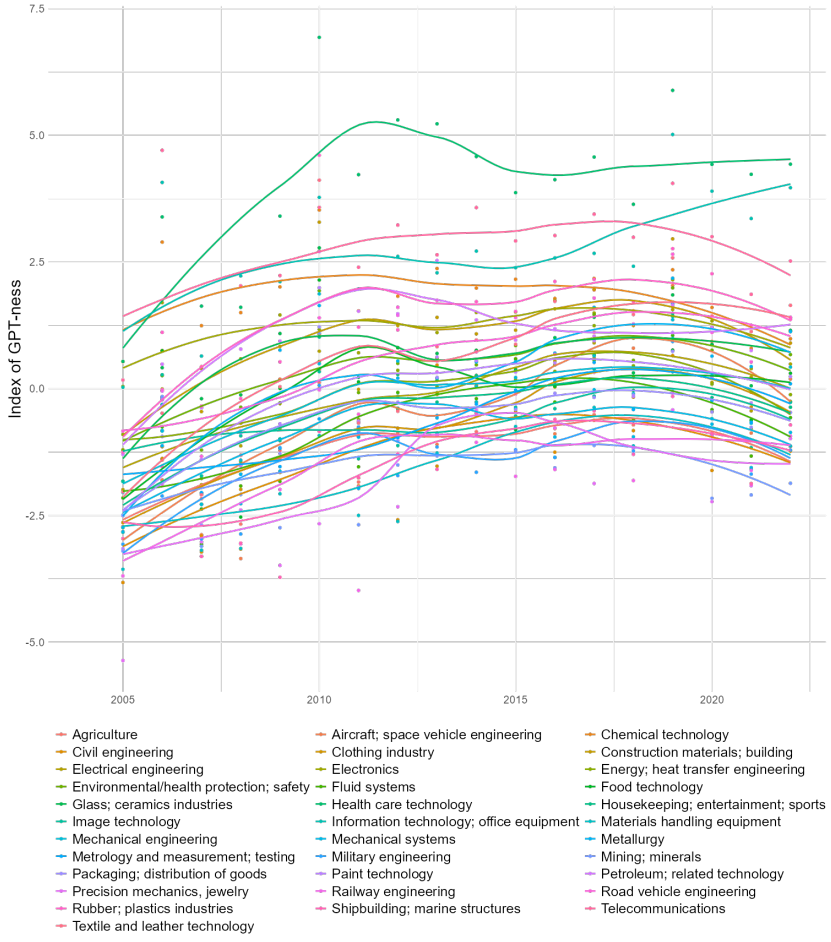

Figure C.1: Index of the degree to which various technologies are general-purpose.

Data on standards

- **Negotiation time:** Continuous. Time (in days) between stage 10.99 New Project Approved and stage 60.00 International Standard under publication.
- **Pages:** Continuous. Number of pages the standard counts.
- **Productivity:** Continuous. Pages divided by negotiation time.
- **Returned:** Binary. Whether a standard has been through any of the stages *10.92 Proposal returned to submitter for further definition*, *30.92 CD referred back to Working Group*, *40.92 Full report circulated: DIS referred back to TC or SC*, *50.92 FDIS or proof referred back to TC or SC*.
- **Readability:** Continuous. 23420 out of 27528 standards had an abstract. 13 abstracts were French, and thus translated to English using DeepL before readability was measured. The readability measure is calculated using the Flesch reading ease score of the standards' abstracts. 4108 standards did not have any abstract, and for these, a linear imputation method was used based on edition, pages, ICS number and committee sector. The final complexity variable has 2996 missing values.
- **Edition:** Continuous. The edition of the standard.
- **ICS number:** Categorical. The standards' category as classified by the International Classification for Standards (ICS). To avoid overfitting the model with two many parameters, only the first two numbers of the ICS code is used. A full list of two-numbered ICS categories can be found in table C.1.

Table C.1: List of ICS fields

ICS Number	Field
01	Generalities. Terminology. Standardization. Documentation
03	Services. Company organization. Management and quality. Administration. Transport. Sociology
07	Natural and applied sciences
11	Health care technology
13	Environment. Health protection. Safety
17	Metrology and measurement. Physical phenomena
19	Testing
21	Mechanical systems and components for general use
23	Fluid systems and components for general use
25	Manufacturing engineering
27	Energy and heat transfer engineering
29	Electrical engineering
31	Electronics
33	Telecommunications. Audio and video engineering
35	Information technology
37	Image technology
39	Precision mechanics. Jewellery
43	Road vehicles engineering
45	Railway engineering
47	Shipbuilding and marine structures
49	Aircraft and space vehicle engineering
53	Materials handling equipment
55	Packaging and distribution of goods
59	Textile and leather technology
61	Clothing industry
65	Agriculture
67	Food technology
71	Chemical technology
73	Mining and minerals
75	Petroleum and related technologies
77	Metallurgy
79	Wood technology
81	Glass and ceramics industries
83	Rubber and plastic industries
85	Paper technology
87	Paint and colour industries
91	Construction materials and building
93	Civil engineering
95	Military affairs. Military engineering. Weapons
97	Domestic and commercial equipment. Entertainment. Sports
99	(No title)

Data on committees

- **Average geographic distance:** Bilateral geodesic distance between capital cities (km). Based on the *distcap* measure from the CEPII Gravity dataset (202211 version) from Conte et al. (2022). The mean of dyads is taken for every TC-year.
- **Share preferential trade agreements:** Based on the number of recorded agreements in the DESTA dataset provided by Dür et al. (2014). For dyads in which there was no recorded PTA in the observation year, the variable is given the value 0. The count is divided by the number of P-members in the TC to produce the share. The share is taken for every TC-year.
- **Average bilateral trade:** Bilateral trade is measured as a share of GDP. Trade is taken from the UN Comtrade database, i.e. summing up across product codes. Measure of bilateral trade is based on exports. To obtain undirected dyads, the average of exports between two countries is used. The mean is taken for every TC-year.
- **Average bilateral tariffs:** Bilateral tariff is measured as share of GDP. The cost of tariffs is gathered from the UN Comtrade database, i.e. summing up across product codes. Measure of bilateral tariffs is based on import. To obtain undirected dyads, the average of tariffs between two countries is used. The mean is taken for every TC-year.
- **Average regime distance:** Distance between countries' democracy scores. Based on the Electoral Democracy Index, i.e. the *v2x_polyarchy* variable from the Varieties of Democracy dataset in Coppedge et al. (2024). Measured as the absolute value of the difference between dyadic scores, so that 0 is having the exact same score and and 100 is being on opposite ends of the scale. The mean is taken for every TC-year.
- **Average UN voting distance:** Ideal point distance, using the *absidealdiff* variable, which is the absolute distance between country 1 and country 2 posterior mean ideal point estimates based on roll-call votes in the UN General Assembly 1946-2017, available from Bailey et al. (2017). The mean is taken for every TC-year.
- **Share defensive alliances:** Countries that have signed formal defense agreements, based on the *atopally* varible in the ATOP 5.1 dataset, from Leeds et al. (2002). The dataset is updated until 2018, and the variable takes the value 1 if the state is a member of any military alliance during the year of observation. The count is divided by the number of P-members in the TC to produce the share. The share is taken for every TC-year.

- **Average UNGA mentions:** The average number of times country A mentions country B and country B mentions country A in UNGA debates. Data from Djuve and Søyland (forthcoming). The mean is taken for every TC-year.
- **Share defensive alliances:** Countries that have signed formal defense agreements, based on the *atopally* varible in the ATOP 5.1 dataset, from Leeds et al. (2002). The dataset is updated until 2018, and the variable takes the value 1 if the state is a member of any military alliance during the year of observation. The count is divided by the number of P-members in the TC to produce the share. The share is taken for every TC-year.
- **Share strategic rivals:** Data based on Dreyer and Thompson (2011), structured through the *peacescienceR* package by Miller (2022). Gives the value 1 to dyads in strategic rivalry – "two states that view each other as threatening competitors to the point that they categorize their antagonists as enemies". The data ends in 2012. The count is divided by the number of P-members in the TC to produce the share. The share is taken for every TC-year.

C.0.3 Descriptive statistics

Variables used in the first analysis can be found in Table C.3. The Flesch Reading Ease score usually returns a score between 0 and 100, but the high complexity of the standard abstracts results in some documents having values below zero. For example, the document scoring -123 (the lowest) has the abstract: "This document specifies methods for the determination of the selected Aconitum alkaloids, including aconitine, mesaconitine, hypaconitine, benzoylaconine, benzoylmesaconine, benzoylhypaconine, yunaconitine, deacetyl-yunaconitine and crassicauline A."

There are on average 22 P-members in a TC. The largest is TC 176, "Quality management and quality assurance", with 95 members. The smallest TCs only had one P-member, likely because they were in a transition phase away from being operative. For example, JTC 1/SC 25, "Interconnection of information technology equipment", had one member in 2019 but zero members in 2025.

Table C.2: Descriptive statistics for H1.

Statistic	N	Mean	St. Dev.	Min	Max
Cosine	22,256	0.120	0.059	0.000	0.309
GPT index	60,416	0.188	1.848	−5.363	6.933
GPT 1	66,693	0.247	0.432	0	1
GPT 2	66,693	0.346	0.476	0	1
GPT 3	66,693	0.564	0.496	0	1
Spec. Tech.	66,693	0.400	0.490	0	1
Patents/GDP	11,872	0.012	0.063	0.000	1.912
Democracy	43,002	0.604	0.265	0.015	0.926
GDP growth	31,251	2.116	4.062	−27.078	29.858
Sci. & tech. articles	32,138	13,855.730	40,400.460	0.000	426,165.300
Tech. in R&D	12,618	716.728	757.438	2.017	3,402.484
Urban pop.	32,568	15,637.260	53,452.800	0	526,464

Table C.3: Descriptive statistics for H2 and H3.

Statistic	N	Mean	St. Dev.	Min	Max
Negotiation time	18,470	918.029	487.117	1	3,386
Number of pages	21,352	32.663	97.049	1	5,656
Productivity	18,461	0.108	1.829	0.001	152.667
Productivity logged	18,461	−3.866	1.254	−7.560	5.028
Flesch reading ease score	21,372	33.530	15.856	−123.100	101.165
Edition	22,026	1.691	1.061	1	12
Average distance (capitals)	20,121	5,868.235	988.032	1,224.833	10,313.210
Share pref. trade agreements	20,158	0.374	0.635	0.000	5.613
Average bilateral trade	21,972	0.006	0.002	0.001	0.021
Average bilateral tariffs	20,803	0.007	0.002	0.001	0.031
Average regime distance	21,972	0.227	0.063	0.017	0.460
Average UN voting distance	11,605	0.932	0.187	0.235	1.572
Average UNGA mentions	21,972	0.167	0.113	0.000	1.250
Share defensive alliances	16,647	5.817	1.772	0.000	13.093
Share strategic rivals	7,415	0.127	0.068	0.000	0.444

C.0.4 Table

Table C.4: Random effects model: TC composition and committee productivity.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Average geographic distance	0.017								
	(0.016)								
Share preferential trade agreements		0.064+							
		(0.034)							
Average bilateral trade			−0.045						
			(0.028)						
Average bilateral tariffs				−0.074*					
				(0.031)					
Average regime distance					−0.022				
					(0.019)				
Average UN voting distance						0.011			
						(0.026)			
Average UNGA mentions							−0.025+		
							(0.015)		
Share strategic rivals								−0.040+	
								(0.022)	
Share defensive alliances									0.113*
									(0.052)
Complexity	−0.011	−0.011	−0.008	−0.006	−0.008	−0.024**	−0.009	−0.022*	−0.015+
	(0.009)	(0.009)	(0.009)	(0.010)	(0.009)	(0.009)	(0.009)	(0.010)	(0.009)
Edition	0.026*	0.014	0.036*	0.012	0.030*	−0.011	0.033*	0.007	−0.012
	(0.013)	(0.011)	(0.016)	(0.012)	(0.014)	(0.020)	(0.014)	(0.044)	(0.015)
Num.Obs.	16 995	17 032	18 412	17 380	18 412	10 080	18 412	6508	14 419
R2 Marg.	0.103	0.111	0.105	0.108	0.102	0.144	0.101	0.154	0.131
R2 Cond.	0.277	0.277	0.286	0.290	0.288	0.322	0.283	0.332	0.306
ICC	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
RMSE	0.78	0.79	0.77	0.77	0.78	0.76	0.78	0.72	0.79
Time series	2004-2020	2004-2020	2004-2021	2004-2021	2004-2021	2004-2014	2004-2021	2004-2010	2004-2018

+ p <0.1, * p <0.05, ** p <0.01, *** p <0.001.
Fixed effects by year, random effects by committee.
Clustered standard errors by committee.
Includes standards that are Published and Withdrawn.

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