Political Science Research and Methods (2026), **14**, 87–105
doi:10.1017/psrm.2025.3

ORIGINAL ARTICLE

Presenting the *StanDat* database on international standards: improving data accessibility on marginal topics

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(Received 11 December 2023; revised 19 September 2024; accepted 23 September 2024)

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.

Keywords: data collection; web scraping; database; standards

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 (Marx *et al.*, 2012; De Vries *et al.*, 2018). 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 (Swann, 2010; Blind *et al.*, 2023). It can also be used to address questions related to the legitimacy of standards as regulatory instruments (Bernstein and Cashore, 2007) and how standardization can serve as a source of power (Rühlig, 2023).[1]

[1]See Table 2 for elaboration.

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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 have 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 and 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).

2. The politics of standards

Research on standards and standardization is incredibly diverse. First, studies span several disciplines, including management studies (Narayanan and Chen, 2012; Wiegmann *et al.*, 2017), organizational studies (Brunsson, 2002; Botzem and Dobusch, 2012), law (Pauwelyn *et al.*, 2012), economics (Weitzel *et al.*, 2006; Swann, 2010; Yang, 2023), sociology (Timmermans and Epstein, 2010), political science (Abbott and Snidal, 2001; Mattli and Büthe, 2003; Büthe and Mattli, 2011a; Graz, 2019), and more recently, multidisciplinary approaches (Eliantonio and 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 and Ellingsen, 2020), and the environment (Prakash and 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 and 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 and Dobusch, 2012, p. 739) and represents the "values against which people, practices and things are measured" (Loconto and 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 (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

[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).

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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 and Snidal, 2001), and today many scholars view standard setting bodies as a part of a "power triangle" that govern socio-economic affairs (Higgins and 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.

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

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 and 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 and 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 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 and 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 (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) (Hallström, 2008; Hallström and 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).

[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 and 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).

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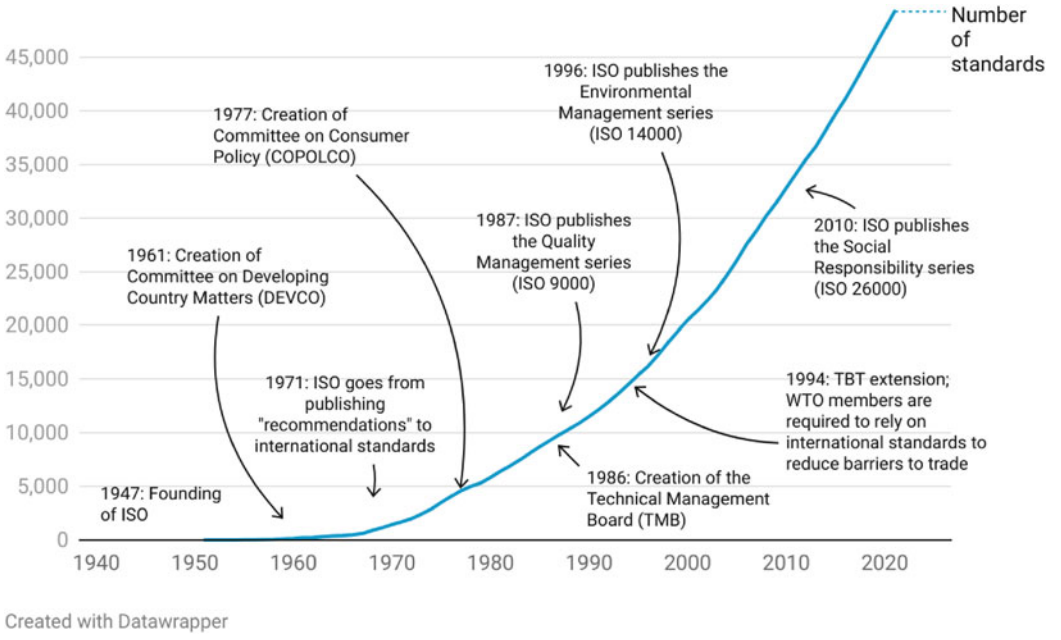


Figure 1. Growth of ISO standards over time annotated with selected notable events in ISO's history.

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 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).

4. The StanDat database

StanDat is a database comprised of four parts; "Standards," "TC-membership," "Historical," and "Certifications," where each part contains 2–3 individual datasets. Units and time series coverage varies across the datasets, as shown in Table 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 web scraping 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 B.

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

[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.

[6]The codebook is available in Appendix A.

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Table 1. Overview of the StanDat database

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 web scraping.
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.

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 and Waddell, 2017; Cavallo, 2018) and introducing frameworks on how to use web scraping to collect data on specific topics (Braun *et al.*, 2018; Anglin, 2019). 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.

In essence, StanDat is created through three different procedures. The first procedure collected data for the "Standards" datasets (first row in Table 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 web scraping—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]

[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.

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Information gathered from the Wayback Machine is limited in two senses. First, the time series 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 B and validated in Appendix C. While data are 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 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 and 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 results 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 *et al.*, 2020; Krotov and Johnson, 2023). Adhering to these ethical guidelines and respecting web crawling limitations outlined in ISO's *robots.txt* document, I ensure compliance. Data are 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.

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

[8]The average accuracy including year 2002 is 76.83.
[9]For more information, see www.iso.org/the-iso-survey.

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standards and other phenomena such as patents, global value chains, or, as demonstrated in section 6, trade.[10]

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 2. Such descriptive data enrich 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 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 4, which shows the increased establishment of technical committees within the new societal sectors that Ruwet (2011) highlights.

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 technology (Kim *et al.*, 2020), Figure 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.

5.2. Assess scope conditions

The encompassing data in the StanDat database enable 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 and Naveh, 2006) or product innovation (Manders *et al.*, 2016), or why firms want to pursue certification in the first place (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 are 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 6.

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

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

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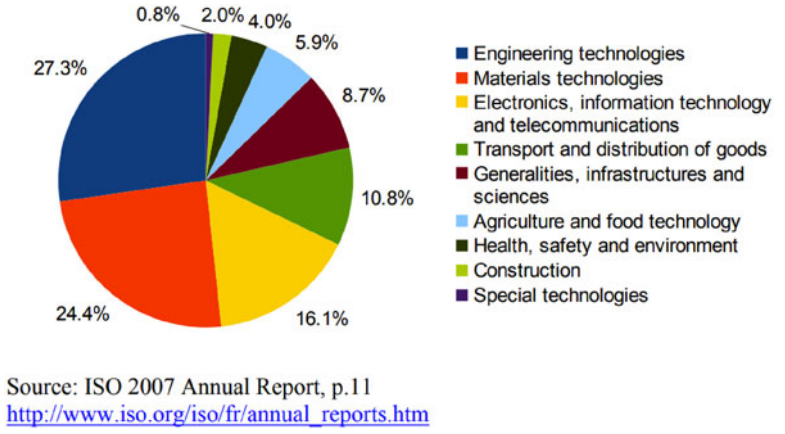


Figure 2. Original illustration of proliferation and diversity of standards from Ruwet (2011).

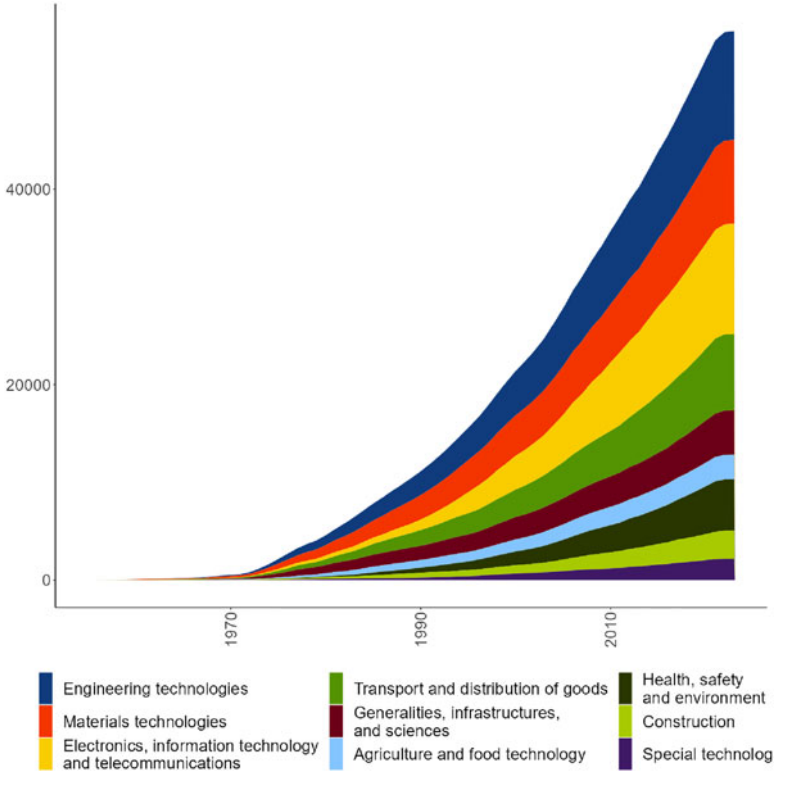


Figure 3. Illustrating the proliferation and diversity of standards (Ruwet, 2011). Cumulative count of standards over time disaggregated by sector, 1950–2023.[11]

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

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

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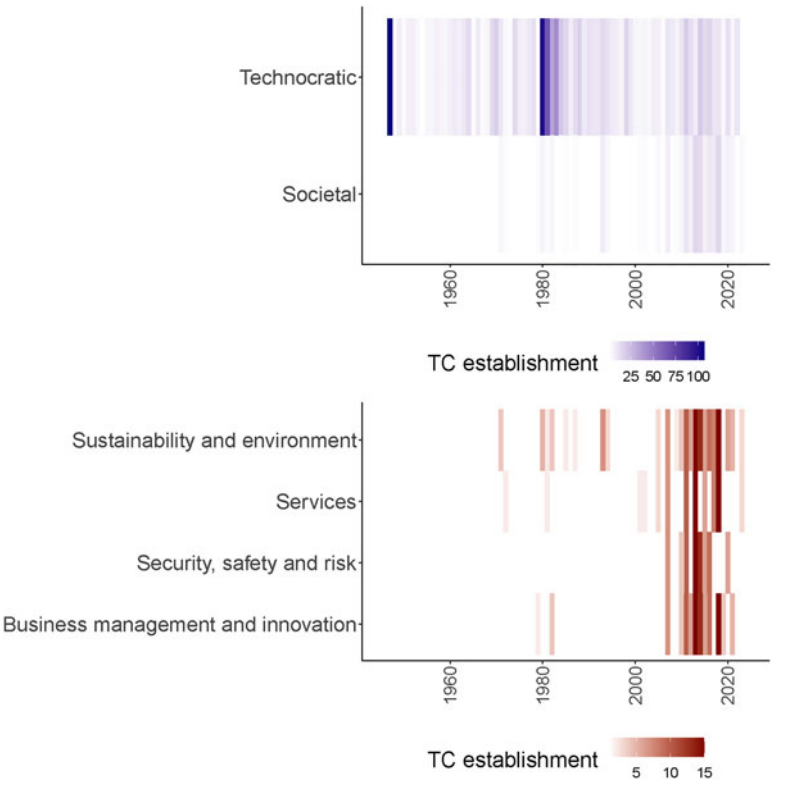


Figure 4. Illustrating ISO's shift toward making standards on societal issues (Ruwet, 2011). Establishment of technical committees within technical and societal issue areas, 1950–2023.

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 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.

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 2. In Appendix E, I provide an example of such an analysis, demonstrating that membership in

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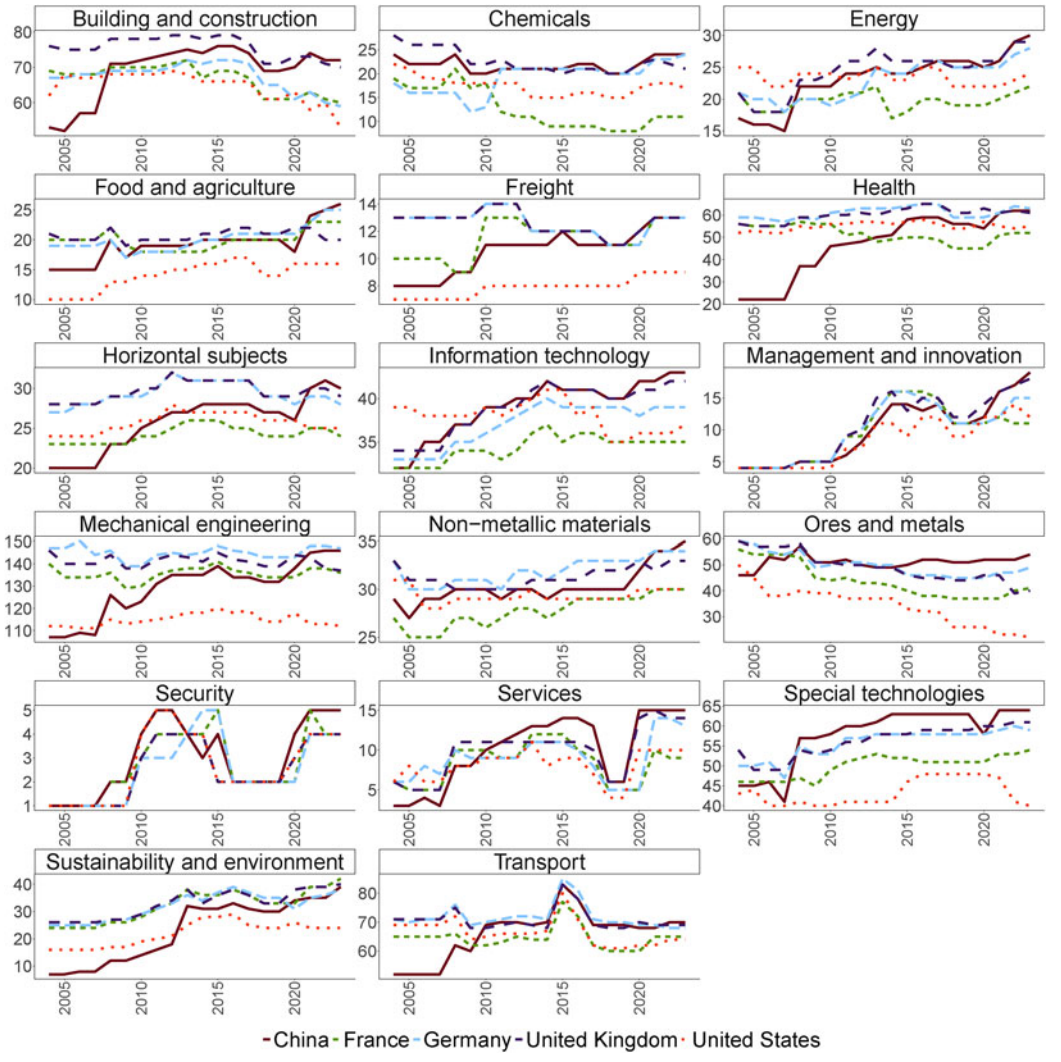


Figure 5. P-membership in technical committees (TCs) and subcommittees (SCs) in the period 2004–2023 for the most active countries as noted by Rühlig (2023).

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 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 (e.g., 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.

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 have found a

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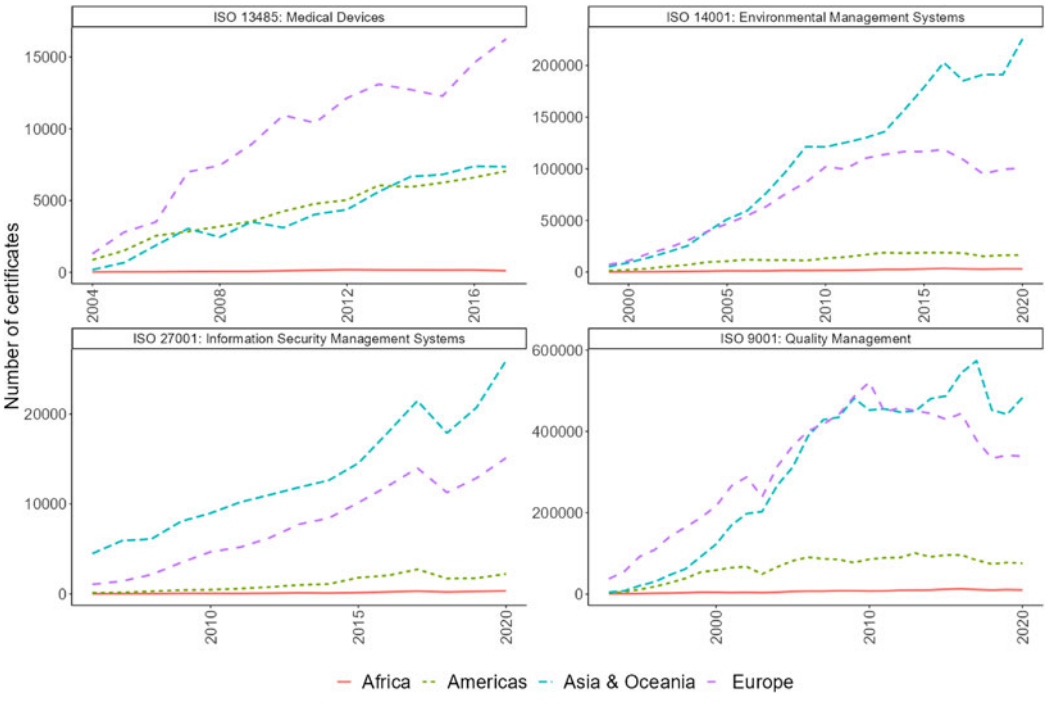


Figure 6. Number of valid certificates issued by IAF accredited certification bodies per year for selected ISO standard series, various time series.[12]

generally positive relationship between adoption of international standards and trade (Swann, 2010; Mangelsdorf, 2011; Blind *et al.*, 2018). 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 and 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 (Mattli and Büthe, 2003; Blind and von Laer, 2022). 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; signaling 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

[12]Certifications in Africa are limited but not nonexistent.

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

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), Swann (2010) and Ding (2024)	*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 standard more similar to treaties texts than physical standards?	Bernstein and Cashore (2007), Ruwet (2011), Mena and Palazzo (2012)	*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?	Nadvi (2008) and Baglioni *et al.* (2020)	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?	Louis and Ruwet (2017) and Jansen (2010)	*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)

the power of actors based on their connections and relative positions within these networks (Farrell and 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 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 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.[13]

Table 4 presents various models examining the relationship between a directed dyads' TC connections and bilateral trade.[14] 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 and 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 (Anderson, 2011), a method recently used by for example Carter and Poast (2020).

The models employ progressively more controls, detailed in Table 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 add 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 F9.

Table 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 1 percent is indicative of a 7 percent increase in bilateral trade volumes. These results are mostly stable throughout various model 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 F).

However, three points should be made. First, the significantly positive coefficient becomes insignificant when adding the last set of control variables. Sensitivity checks suggest 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 F18). Second, when controlling for R&D intensity, the TC coefficient remains 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

[13]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).

[14]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.

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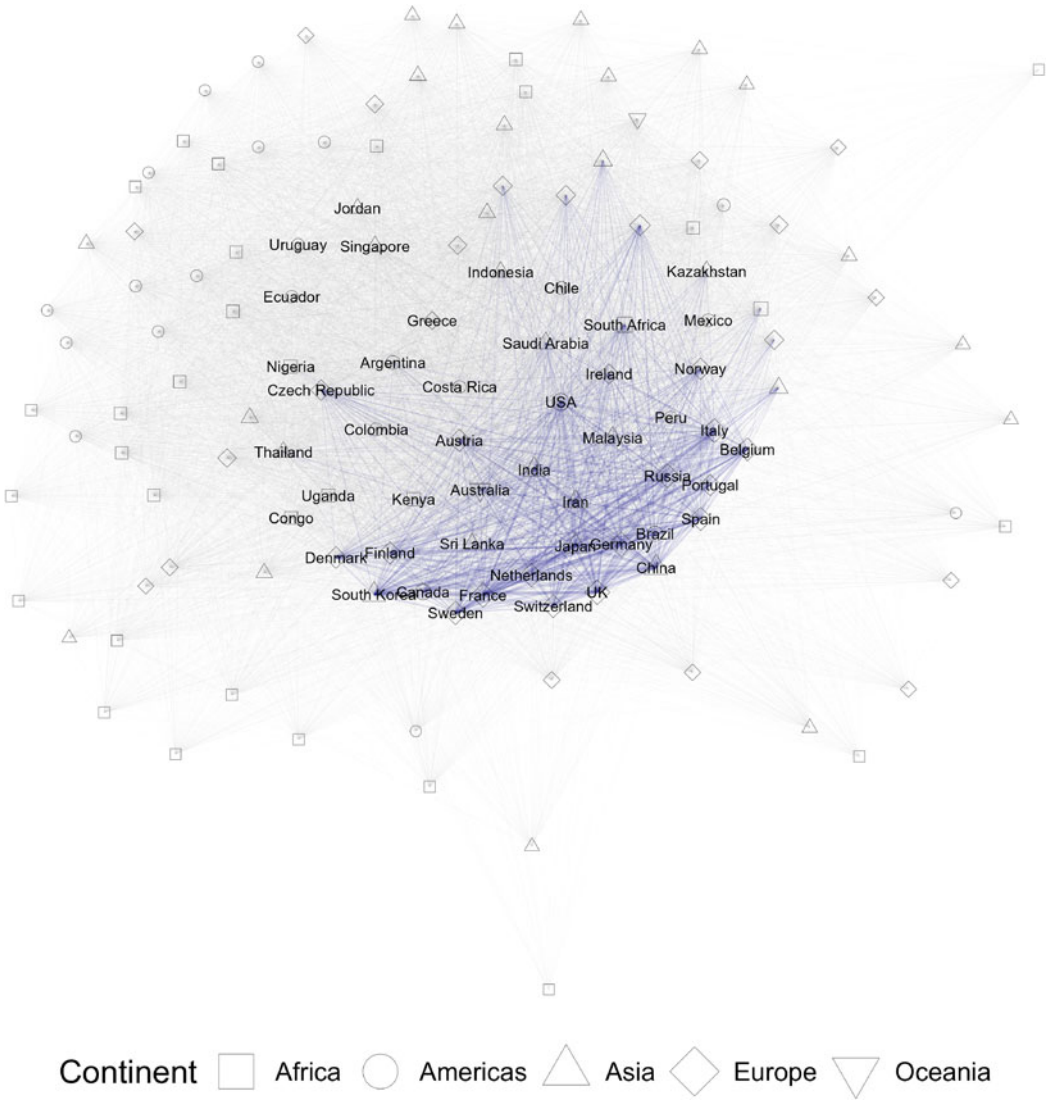


Figure 7. Countries sharing P-membership in technical committees, 2022. The size of the node indicates how many TCs the country participates in. A link between the nodes means that the countries participate in the same TC. The size of the link indicates how many TCs the countries share.

Table 3. Control variables in Table 4

Model	Control variables	Source
Gravity	Regional trade agreement	CEPII Gravity Database (Conte *et al.*, 2022)
	WTO member dyad	
Gravity+R&D	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	DESTA Database (Dür *et al.*, 2014)
	Common currency	de Sousa (2012)
Gravity++	Alliance	Correlates of War (Gibler, 2009)
	Strategic rivalry dyad	Miller (2019)

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Table 4. Relationship between dyadic TC connections and trade volume

	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.	402385	346684	229574	190173	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

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

removing zero imputation on missing dyads from the standardization network renders the coefficient on "Gravity+R&D" insignificant (see Appendix Table F16). 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 F19). 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 and 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.

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 and 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

https://doi.org/10.1017/psrm.2025.3 Published online by Cambridge University Press

inequality or climate change. Because of the interdisciplinary nature 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 are publicly available on the internet, this paper demonstrates the viability of transforming that into research data.

Supplementary material. The supplementary material for this article can be found at https://doi.org/10.1017/psrm.2025.3. To obtain replication material for this article, Replication Link: https://doi.org/10.7910/DVN/HA8HFW.

Competing interests. None.

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Cite this article: Bjørkholt S (2026) Presenting the *StanDat* database on international standards: improving data accessibility on marginal topics. *Political Science Research and Methods* **14**, 87–105. https://doi.org/10.1017/psrm.2025.3

https://doi.org/10.1017/psrm.2025.3 Published online by Cambridge University Press