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Fields of harmony: trade standards and China's value-added exports in global value chains

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ABSTRACT

This study uses a gravity model to analyse the effects of different trade standards on China's value-added and total exports in global value chains (G.V.C.s). The results indicate that harmonisation with international standards promotes both types of exports in China. Hence, the country should not neglect the implementation of standards. Mandatory standards have a greater impact on exports than voluntary standards. In addition, mandatory internationally harmonised standards have a greater trade promotion effect on total exports than on value-added exports. Voluntary country-specific standards have a greater trade inhibiting effect on value-added exports than on total exports. Voluntary internationally harmonised standards do not show statistically significant impacts on either export type. Therefore, emerging economies should optimise the scale and structure of standards, ensure their implementation, and improve their international harmonisation to promote exports and reap the benefits of joining G.V.C.s.

1. Introduction

Global value chains (G.V.C.s) and global production networks have gained prominence in the international political economy (Neilson et al., 2014). Over the past two decades, G.V.C.s have reduced trade barriers, lowered transportation costs, created jobs, reduced consumer prices, and driven significant economic growth in emerging economies (The World Bank, 2019). International trade has formed a complex network of cross-border flows of goods, services, capital, and technology. Evidence suggests that the productivity elasticity of G.V.C. participation is greater than 1% (The World Bank, 2020). Before the COVID-19 pandemic, 80% of global trade involved G.V.C. enterprises, amounting to approximately US$20 trillion in 2019 (Strange, 2020). Participation in G.V.C.s has increased traders' vulnerability to the COVID-19 shock, but has reduced their susceptibility to domestic shocks (Espitia et al., 2022). Hence, G.V.C.s seem to have sufficient safety margins to withstand the global economic crisis caused by the COVID-19 pandemic (Varnavskii, 2021). For G.V.C.s to

keep driving economic development in post-pandemic environments, emerging economies need to improve connectivity, and industrial economies need to pursue open and predictable policies. Greater international cooperation is necessary to achieve these goals. The World Bank (2019) has pointed out that a country's public policies and economic conditions affect trade partners through production linkages. The benefits of coordinated policies are greater for G.V.C.s than for conventional trade, as goods and services cross borders multiple times.

G.V.C.s involve a series of value-added stages for producing and selling goods and services; at least two of these steps are completed in different countries. For example, the production and sales of Apple products, including procuring raw materials and intermediate inputs, will span multiple continents before the assembly process will be completed in one country; later, these Apple products will be sold globally. If a country participates in at least one stage, it becomes a part of the G.V.C., based on a cross-border production model that creates higher requirements for trade coordination between countries. The goods and services produced by the participating countries must follow common quality checks and production norms established by international standardisation bodies. Trading enterprises must follow a series of product and process standards to participate in G.V.C. production. International market actors exclude companies that do not comply with international standards from the global market. Harmonisation, compatibility, and consistency with international standards are prerequisites for countries to enter G.V.C.s (Blind et al., 2018; Nadvi, 2008). Therefore, they cannot ignore internationally set standards, which strengthen the competitive advantage of trade enterprises and a country's competitive advantage, thereby affecting trade (Blind et al., 2018; Nadvi, 2008; Swann, 2010).

This study analyses the impact of technical standards on China's total and G.V.C. exports. There are four reasons to highlight its importance and relevance: (1) China revised its standardisation law in 2017 and issued a national standardisation development outline in 2021. As a result, standards now play a crucial role in its foreign trade;[1] (2) China has a comparative advantage in middle- and low-end manufacturing, but the domestic value of its exports is relatively low. Thus, the harmonisation of standards enhances China's participation in G.V.C.s; (3) China's country-specific and internationally harmonised standards have gradually expanded (Yang, 2021), and it is also the world's largest exporter of goods; and (4) No empirical study has investigated the effect of country-specific and internationally harmonised standards on China's value-added and total exports in G.V.C.s. This study is the first to address these open issues.

2. Literature review and theoretical framework

2.1. Standards and exports

The literature distinguishes between mandatory and voluntary standards, and between country-specific and internationally harmonised standards. These different standards form competitive advantages and disadvantages through the intermediate effects of economies of scale, labour division, competitiveness, entry barriers, network effects, transaction costs, trust, and risk. Based on these noted considerations, standards

affect exports, either positively or negatively (Blind & Müller, 2019; Shepherd, 2015; Swann, 2010).

Previous findings regarding country-specific and internationally harmonised standards are mixed, and even contradictory. The representative conclusions are as follows: (1) Both country-specific and internationally harmonised standards promote exports (Blind, 2004; Curzi et al., 2018; Mangelsdorf et al., 2012; Moenius, 2006; Swann, 2010); (2) Both country-specific and internationally harmonised standards inhibit exports. Still, the inhibitory effect of internationally harmonised standards is smaller, as shown by the exports of textiles and clothing from sub-Saharan African countries to the European Union (Shepherd, 2015); and (3) Country-specific standards are not conducive to exports, whereas internationally harmonised standards promote them (Blind, 2004; Blind et al., 2018; Karemera et al., 2020; Mangelsdorf, 2011; Portugal-Perez et al., 2010).

Moreover, mandatory standards promote exports by improving the international competitiveness of trade enterprises in emerging countries (Vieira, 2006). Mandatory and voluntary standards increase enterprises' production costs, negatively affecting exports. Country-specific standards may be a reasonable expression of the national environment and preferences. However, if the cost of adopting internationally harmonised standards is too high, harmonisation may not always promote exports (Shepherd, 2015). Mandatory food standards inhibit agri-food exports (Medin, 2019). The higher the trade concentration between standard-setting countries and trading partners, the lower the adverse effects (Fiankor et al., 2021).

2.2. Standards and G.V.C.s and theoretical framework

Compliance with international standards is critical to maintaining G.V.C.s (Nadvi, 2008). Enterprises in emerging countries face distinct product and process standards. This phenomenon has heightened their competitive challenges, as non-compliance with international standards results in their exclusion from global markets. Loconto and Busch (2010) have investigated the tripartite standards regime (T.S.R.) (i.e., standard-setting, accreditation, and certification) by examining the pragmatic emergence of standard development organisations (S.D.O.s) and national accreditation bodies (N.A.B.s). The authors explain how the T.S.R. contains intermediaries and processes in specific supply chains across their network of audits. The concept of standards captures the complex underlying processes involved in T.S.R. construction. This body of research has presented evidence based on data from S.D.O. and N.A.B. websites, official documents, international trade agreements, and directories published by the National Institute of Standards and Technology, and the International Organization for Standardization (I.S.O.). T.S.R. acts as a global techno-economic network, playing a critical coordinating role in facilitating international trade. Thus, T.S.R. is fundamental to achieving good governance at a distance, as entailed in the neoliberal shift from government to governance.

Empirical research has examined the impact of formal standards on trade in G.V.C.s. In North–South trade, the vital role of standards lies in their power to enable market access and participation in the higher-value-added stages (Fricke &

Chapman, 2017). This phenomenon is critical for sub-Saharan African countries that want to participate in the global market and higher value-added stages of their G.V.C.s. Blind and Müller (2019) have estimated the influence of national, European, and international standards on trade in value-added and gross trade flows within Europe. They contend that national standards hamper trade in European value chains, whereas European and international standards foster trade.

Furthermore, European standards have a greater influence on trade in the intra-European value chains, whereas international standards positively affect imports into Europe from emerging economies. European standards reduce the information asymmetries between enterprises in European single-market value chains. International standards affect global communication between international partners. In addition, these standards positively affect the interaction between national and European standards in European value chains, further confirming the need for international standardisation.

Based on extant literature, this study proposes a theoretical framework to analyse the influence of standards on a country's participation in G.V.C. production and sales. As mentioned earlier, standards may impact exports positively or negatively, and different standards have heterogeneous effects on exports. Quality standards and country-specific or internationally harmonised standards may increase competitiveness and promote China's exports. Enterprises within G.V.C.s trade as networks, and the formation of a trade network results from a country's choice to comply with international standards. Internationally harmonised standards produce a common language among trading countries, which is conducive to exporting products to the international market. Combined with competitive and common language effects, internationally harmonised standards play a more critical role than country-specific standards in promoting value-added and total exports of goods with trading partners.

However, country-specific or internationally harmonised standards have substantial cost effects. When an enterprise adapts its facilities and processes to a standard, its costs increase. Domestic market actors may enjoy a favourable position when they comply with country-specific standards. In contrast, following internationally harmonised standards increases compliance costs in trade enterprises' production, operation, and sales, which are not conducive to promoting exports.

China's standardisation law stipulates the implementation of mandatory standards. Products that do not meet mandatory standards are not produced or sold, and enterprises bear the legal repercussions of violating mandatory standards. The state encourages enterprises to adopt voluntary standards and undertake preferential measures toward this aim. Therefore, the enforcement effect of mandatory standards is greater than that of voluntary ones.

Overall, the literature suggests that standards positively affect China's participation in G.V.C. trade through the competitive and common language effect (Blind & Müller, 2019; Fricke & Chapman, 2017; Loconto & Busch, 2010; Nadvi, 2008). In contrast, standards negatively affect its participation via the compliance cost effect. Laws and regulations guarantee China's mandatory standards, and competitiveness, common language, and cost effects are stronger in mandatory standards than voluntary standards. Therefore, the final impact of national standards on China's

Table 1. Effects of standards on China's total exports and value-added exports in GVCs.

		Trade effects			
		Value-added export		Total export	
Standards		Positive	Negative	Positive	Negative
Country-specific standards	Mandatory	Competitive effect	Cost effect	Competitive effect	Cost effect
	Voluntary	Competitive effect	Cost effect	Competitive effect	Cost effect
Internationally harmonised standards	Mandatory	Competitive effect; common language effect	Cost effect	Competitive effect; common language effect	Cost effect
	Voluntary	Competitive effect; common language effect	Cost effect	Competitive effect; common language effect	Cost effect

Note: Blue boxes indicate that the effect in the box is strengthened: the darker the colour, the stronger the effect. The impact of mandatory standards is strengthened, while the effect of voluntary standards is weakened. The cost effect of country-specific standards is weaker than that of internationally harmonised standards.
Source: Original material from the author.

participation in G.V.C. trade depends on the relative levels of competitiveness, common language, and cost effects. Although the first two impacts are conducive to forming a trade network, the cost effect may offset the positive impact of standards on G.V.C. trade (see Table 1). This study applies a gravity model to investigate the net effects of different standards on China's value-added and total exports in G.V.C.s.

3. Descriptive statistics

This study uses panel data, including China's national standards and trade data of value-added and total exports to 61 countries and one area.[2] We obtain national standard data from the China National Standardization Administration Committee (S.A.C.) and data on China's value-added exports and total exports from the Organisation for Economic Co-operation and Development–World Trade Organization's (O.E.C.D.-W.T.O.) global value-added trade statistical database (T.I.V.A.). The O.E.C.D.-W.T.O. T.I.V.A. database distinguishes major countries' value-added and total exports from 2005 to 2015, avoids the possible double statistics of imports and exports at the macro level, and provides data support for trade research on G.V.C.s.

In creating a G.V.C., a country exports value-added products and services via domestic production to meet foreign demand (i.e., domestic value-added embodied in final foreign demand). The scale of value-added exports reflects the depth of a country's integration into G.V.C. production. Total exports reflect a country's export scale in a certain period and the volume of goods and services provided to the global market. To unify the calibre and ensure data consistency, our research period aligns with the O.E.C.D.-W.T.O. T.I.V.A. database (latest 2018 edition), namely, 2005–2015.

We obtain G.D.P. information from the World Bank's World Development Index (W.D.I.) database, and price it in constant U.S. dollars in 2010. Furthermore, we gather data for the geographical distance (in kilometres) between China and partner countries from the CEPII Geodist database. We use the correspondence table between the International Industrial Classification (ISIC, 3rd edition) and the international standard classification established by Blind et al. (2018) to classify national standard data and China's value-added and total export data.[3]

Table 2. Descriptive statistics of each variable.

Variable	Definition	Source	Obs.	Mean	Std. Dev.	Min.	Max.
$ln(va)_{jkt}$	ln (value-added export)	TIVA database	682	8.36	1.73	3.74	12.98
$ln(ex)_{jkt}$	ln (total export)	TIVA database	682	8.63	1.80	3.86	13.10
$ln(mst)_{kt}$	ln (mandatory country-specific standards)	SAC	682	6.47	0.49	5.61	7.11
$ln(mist)_{kt}$	ln (mandatory internationally harmonised standards)	SAC	682	5.88	0.54	4.82	6.40
$ln(vst)_{kt}$	ln (voluntary country-specific standards)	SAC	682	8.96	0.58	7.93	9.64
$ln(vist)_{kt}$	ln (voluntary internationally harmonised standards)	SAC	682	8.80	0.40	8.04	9.24
$ln(cc)_t$	ln (unqualified product announcements)	SAMR website	682	5.39	0.40	5.01	6.31
$ln(gdp)_{jt}$	ln (GDP)	WDI	682	26.35	1.65	22.77	30.45
$ln(dis)_j$	ln (bilateral distance between China and trade partner)	CEPII Geodist	682	8.85	0.55	6.86	9.87

Note: j refers to the trading partner, k refers to the trade sector and t is the year. SAC is the Standardization Administration of China.
Source: original material from the author.

Table 2 presents the descriptive statistics for each variable. The average values of China's value-added and total exports indices, $ln(va)_{jkt}$ and $ln(ex)_{jkt}$, are 8.36 and 8.63, respectively, and the standard errors are 1.73 and 1.80, respectively. The minimum and maximum values are 3.74 and 12.98 for value-added indices, and 3.86 and 13.10 for total export indices, indicating a gap between the value-added and total export volumes. The volume of value-added exports is smaller than that of total exports, and the volatility of their scale is lower. For the explanatory variables, $ln(ms)_{kt}$, $ln(vs)_{kt}$, $ln(mis)_{kt}$, and $ln(vis)_{kt}$, the average values of the indices fluctuate between 6.47 and 8.96, the standard errors range between 0.40 and 0.58, the minimum values lie between 4.82 and 8.04, and the maximum values are between 6.40 to 9.64. These results indicate significant differences across the types of national standards.

4. Materials and methods

4.1. Model

This study uses the classical gravity model to investigate the impact of standards on China's exports. The gravity model was introduced by Tinbergen (1963) and refined by Anderson and van Wincoop (2003) and Baier and Bergstrand (2007). They assume that factors other than traditional comparative advantages, such as network effects, geographical proximity, and economic development, influence trade (Blind et al., 2018). Therefore, standards that ensure compatibility and reduce transaction costs are essential for producing network effects. The extended gravity model is widely used in empirical research to understand the impact of standards on international trade (Fiankor et al., 2021; Mangelsdorf, 2011; Mangelsdorf et al., 2012; Moenius, 2006). National standards are categorised into mandatory country-specific standards, voluntary country-specific standards, mandatory internationally harmonised standards, and voluntary internationally harmonised standards in China. Given the endogenous interference of missing variables[4] in the gravity model, we add various control variables to build a multilateral resistance term. Anderson and van Wincoop (2003) have proposed

multilateral resistance terms based on country-specific fixed effects. Following Baier and Bergstrand (2007), we include time- and sector-fixed effects in the proposed model, as follows:

$$\ln (Export)_{jkt} = \beta_0 + \delta_{jk} + \delta_{kt} + \delta_{jt} + \beta_1 \ln (mstd)_{kt} + \beta_2 \ln (vstd)_{kt} + \beta_3 \ln (mistd)_{kt}$$
$$+ \beta_4 \ln(vistd)_{kt} + \beta_5 \ln (cc)_t + \beta_6 \ln (GDP)_{jt} + \beta_7 \ln (distance)_j + \varepsilon_{jkt},$$

(1)

where the dependent variable $\ln (Export)_{jkt}$ is China's exports to country j in sector k in year t. We express exports in constant US dollars (2010). We specify the dependent variable in two ways: (1) $\ln(va)_{jkt}$ for value-added exports and (2) $\ln(ex)_{jkt}$ for total exports. All the trade data are real currency values. The explanatory variables are $\ln(mstd)_{kt}$, $\ln (vstd)_{kt}$, $\ln (mistd)_{kt}$, and $\ln(vistd)_{kt}$, representing the number of mandatory country-specific standards, voluntary country-specific standards, mandatory internationally harmonised standards, and voluntary internationally harmonised standards, respectively, in sector k trade in year t. Using the number of standards before 31 December 2004, we add new annual national standards and subtract the annual repeated national standards. We then record these data as the national standard stock in sector k for that year. To measure the enforcement of national standards,[5] we use the number of unqualified product announcements of random national inspections every year, published by the China Quality News (CQN) website (http://www.cqn.com.cn.), $\ln(cc)_t$. The State Administration of Market Regulation (SAMR) of China manages the CQN website, and the public information released is authoritative and publicly available. A higher number of unqualified product announcements indicates that the government has strengthened the enforcement of such standards.[6]

We build the other control variables based on the classical gravity model. The gross domestic product (GDP) of country j, $\ln(GDP)_{jt}$, proxies the economic mass reflecting the trade potential of partners; $\ln (distance)_j$ is the geographical distance between China and trading country j. To eliminate the influence of heteroscedasticity, we take the natural logarithms of all variables in the model. Parameter δ_{jk} represents country-sector fixed effects, namely, China's long-term trade relationship with the country in a specific sector. Parameter δ_{kt} indicates the sector-year fixed effects, namely, the external impact of a particular type of traded item on the world market in a specific year. Parameter δ_{jt} is the country-year fixed effect, which controls the impact of the country's trade policy and technological change. By including these three-dimensional fixed effects, we eliminate endogeneity concerns to a large extent. Finally, ε_{jkt} is the standard error.

4.2. China's stylised facts regarding the national standard scale and value-added trade

The impact of national standards on China's trade may be divided into three stages: (1) From 1978 to 2000, following the reforms and opening-up policy, China joined the I.S.O. and began focusing on the impact of international safety, health, and environmental protection standards on trade; (2) From 2001 to 2010, after China's access

Table 3. Examples of national standards in China.

Standard no.	Standard name	Enforcement effect	Based on international standards (Yes/No)	Adopted international standard
GB/T 33737-2017	Mobile payment: Test methods for intelligent cards based on 2.45-GHz RRC (range-controlled communication) technology	Voluntary	No	–
GB 6675.13-2014	Safety of toys part 13: Chemical toys (sets) other than experimental sets	Mandatory	Yes	EN 71-5:1993 + A1:2006
GB 7958-2014	Capacitor discharge-type exploders for coal mines	Mandatory	No	–
GB/T 26125-2011	Electrical and electronic products: Determination of six regulated substances (lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls, and polybrominated diphenyl ethers)	Voluntary	Yes	IEC 62321:2008
GB 21536-2008	Athletic shoes	Mandatory	No	–
GB/T 30769-2014	Stainless steel fruit knife	Voluntary	Yes	ISO 8442-1:1997; ISO 8442-5:2004
GB/T 38870-2020	General specifications of slicing robot system	Voluntary	No	–
GB/T 10250-2007	Electrical and electronic installations in ships: Electromagnetic compatibility	Voluntary	Yes	IEC 60533:1999

Source: Standardization Administration of China.

to the W.T.O. and its global economic integration, the country began addressing the impact of WTO labour standards and environmental and food standards on trade; and (3) From 2011 to the present, after China's rejuvenation strategy through quality, the country has begun to improve the national standard system and study the impact of its standards on trade.

As mentioned above, the Chinese national standards are mandatory or voluntary. China's standardis

ation in law (2017) states that mandatory national standards are strictly limited to ensuring personal health, and the safety of life and property, as well as meeting the basic needs of social and economic management. Voluntary national standards are basic and general, match mandatory national standards, and play a leading role in the relevant industries. Mandatory standards must be implemented, and products that do not conform to mandatory standards should not be marketed. Those who violate mandatory standards bear legal liabilities. The government encourages the adoption of voluntary standards.

Table 3 presents the Chinese national standards, namely, country-specific and internationally harmonised standards. The number of voluntary national standards in China has increased during the research period. As a result, the sample has more voluntary standards than mandatory standards and more country-specific standards than internationally harmonised standards (see Figures 1 and 2).

The sample period is characterised by more voluntary country-specific standards than voluntary internationally harmonised standards, and more mandatory country-specific standards than mandatory internationally harmonised standards. On December 31, 2015, China had 1820 mandatory standards, namely, 1220 mandatory country-specific standards and 600 mandatory internationally harmonised standards. As of February 2022, China has 25,721 voluntary standards, including 15,415
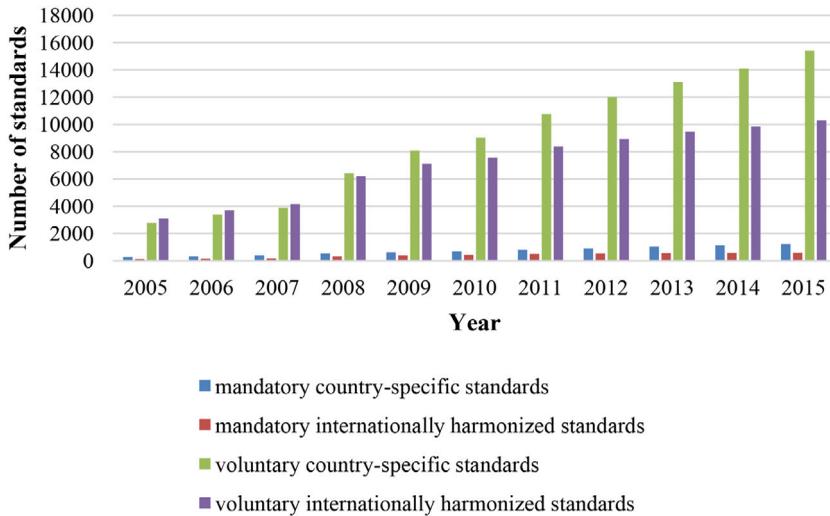
Figure 1. Stock of National Standards (2005–2015).
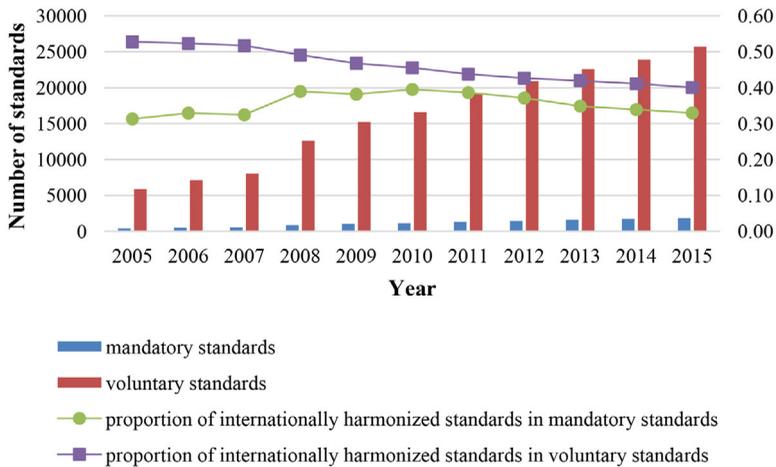Source: Standardization Administration of China.

Figure 2. Stock and proportion of internationally harmonised standards (2005–2015).
Source: Standardization Administration of China.

country-specific and 10,306 internationally harmonised voluntary standards. There are 27,541 national standards, 60.40% country-specific, and 39.60% internationally harmonised standards. The proportions of mandatory country-specific, mandatory internationally harmonised, voluntary specific, and voluntary internationally harmonised standards are 4.43%, 2.18%, 55.97%, and 37.42%, respectively. China's national standards mainly entail voluntary country-specific standards, followed by voluntary internationally harmonised standards. Mandatory country-specific standards and mandatory internationally harmonised standards account for 6.61% of the total.

The number of mandatory and voluntary standards has increased, especially since 2008. The number of mandatory standards was 396 in 2005 but increased to 1820 in 2015. Likewise, the number of voluntary standards increased from 5874 to 25,721, a more than threefold increase over the same period. The proportion of internationally harmonised voluntary standards is always higher than that of mandatory standards. Nevertheless, the former has followed an apparent downward trend, whereas the latter has experienced upward fluctuations. The proportion of internationally harmonised mandatory standards has fluctuated significantly from 2008 to 2010 and dropped to 33% in 2015. However, it is still higher than the initial level of 31% in 2005. Since 2007, the proportion of internationally harmonised standards in China's voluntary national standards has dropped, reaching 40% in 2015, lower than the initial 53% in 2005. The proportion of internationally harmonised standards in mandatory and voluntary standards has followed different trends, revealing the differences in the supply volume of internationally harmonised standards. In contrast, the supply of mandatory and voluntary national standards has increased. In terms of total stock, the number and proportion of mandatory standards are lower than those of the voluntary standards. However, the proportion of voluntary standards has followed a downward trend in terms of international standards.

China's value-added and total exports have increased. However, the gap between the value-added and total exports has widened. In 2015, China's value-added exports were 3.27 times those of 2005, and the total export volume was nearly three times that of the total exports in 2005. During this period, the increase in value-added exports has exceeded that in total exports. Although China's value-added export volume is lower than that of the total exports, their proportion is more than 70%, with the highest value reaching 78% in 2009. In 2011, this value decreased and began exhibiting a clear upward trend (see Figure 3). The data show that the increase in the scale of China's exports has progressively integrated into G.V.C.s.
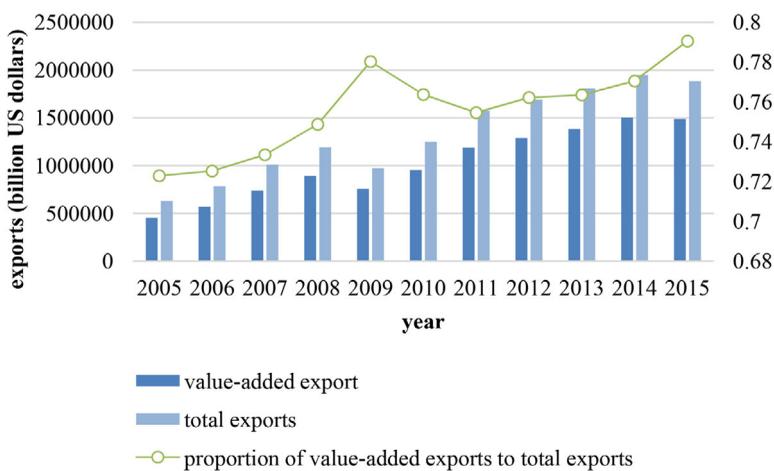

Figure 3. China's value-added exports, total exports, and the proportion of China's value-added exports to total exports (2005–2015).
Source: Organisation for Economic Co-operation and Development–World Trade Organization's global value-added trade statistical database.

5. Results

5.1. Regression results

Table 4 reports the regression results of Model (1). The results in columns (1) and (2) indicate that the growth of the national standard stock promotes China's value-added and total exports, and the standards' trade effect on the former is greater than that on the latter. The results also indicate that China's national standards' competition and common language effects outweigh the costs. The positive effects ensure the quality and safety of export products, support technology and its application, and increase exports.

The results in columns (3) and (4) indicate that mandatory standards have a significant and positive effect on value-added and total exports in China. In contrast, voluntary standards have a significant and negative impact. The trade effect of mandatory standards is the largest. The impact of mandatory and voluntary standards on value-added exports is greater than that of total exports.

The coefficient on voluntary standards is negative and less significant than that on mandatory standards for two reasons. First, the proportion of country-specific standards among the voluntary national standards is high. Trading enterprises have not universally recognised China's voluntary country-specific standards. Voluntary national standards reflect Chinese consumer preferences, although domestic and foreign consumer preferences may differ. Second, voluntary national standards' implementation effect and efficiency need to be improved. Laws and regulations guarantee mandatory national standards, and their effects are stronger than those of voluntary standards. The government encourages enterprises to adopt voluntary national standards, but problems such as aging, overlapping standards, and slow updates affect competition and common language effects. As the National Standardization System Construction and Development Plan (2016–2020) specifies, voluntary standards should be optimised and improved. The number and scale of existing voluntary standards should be reduced gradually.

The results in columns (5) and (6) show that mandatory country-specific standards and mandatory internationally harmonised standards promote China's exports. These standards have a greater positive and statistically significant impact on China's total exports than value-added exports. However, voluntary country-specific and internationally harmonised standards have a greater negative impact on China's value-added exports than total exports. The statistical significance of the adverse effects on value-added exports is higher than that on total exports. Voluntary internationally harmonised standards have a lower negative impact than voluntary country-specific standards on both types of exports and are not statistically significant at the 10% level for two reasons. First, voluntary country-specific standards increase the cost of domestic enterprises adjusting to internationally harmonised standards. Second, ensuring that enterprises follow voluntary standards is challenging. China's standards are mostly voluntary. The negative impact of voluntary country-specific standards on value-added exports is larger than that on total exports. In other words, if the implementation and advancement of voluntary standards cannot be ensured, entering G.V.C.s may be harmful to China.

Table 4. Baseline results.

	(1) Value-added export	(2) Total export	(3) Value-added export	(4) Total export	(5) Value-added export	(6) Total export
Total standards	0.6942*** [0.0435]	0.6362*** [0.0542]				
Mandatory standards			3.1600*** [0.9638]	3.1758*** [1.1946]		
Voluntary standards			−2.5003** [0.9726]	−2.5743** [1.2057]		
Mandatory country-specific standards					2.3166*** [0.6288]	2.3788*** [0.7795]
Voluntary country-specific standards					−2.3632*** [0.8784]	−2.1700** [1.0919]
Mandatory internationally harmonised standards					2.1877* [1.1296]	2.5510* [1.3895]
Voluntary internationally harmonised standards					−1.4566 [2.1192]	−2.3676 [2.6041]
GDP	0.9541*** [0.0162]	0.9682*** [0.0182]	0.9535*** [0.0161]	0.9677*** [0.0182]	0.9535*** [0.0161]	0.9676*** [0.0182]
Distance	−0.1966*** [0.0577]	−0.3396*** [0.0649]	−0.1967*** [0.0574]	−0.3397*** [0.0646]	−0.1967*** [0.0575]	−0.3397*** [0.0647]
Check	−0.0455* [0.0566]	−0.0632* [0.0695]	−0.0915* [0.0574]	−0.1095* [0.0711]	−0.0048* [0.0739]	−0.0244* [0.0909]
Country-year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year-sector-fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Country-sector-fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Constant	−21.4930*** [0.7816]	−19.6840*** [0.9195]	−12.4230*** [2.8280]	−10.5719*** [3.5055]	−8.8552 [8.3705]	−3.8447 [10.2947]
Observations	682	682	682	682	682	682
R^2	0.8912	0.8493	0.8928	0.8508	0.8933	0.8512
F	957.2369	757.9812	775.2958	611.2996	553.4482	436.6143

Note: Standard errors are in brackets. *, ** and *** indicate 10%, 5% and 1% significance levels, respectively. The F-test results are significant at the 1% level.
Source: original material from the author.

These results show that mandatory country-specific standards guarantee the quality of China's export commodities, increasing its export volume. The impact of mandatory country-specific standards on China's total trade exports is greater than that of value-added exports. The mandatory internationally harmonised standards also guarantee China's participation in G.V.C. production. The CC/Check variable has a negative impact on trade volume and is significant at the 10% significance level, which means the enforcement of national standards has a negative and significant impact on trade volume.

In addition, growth in G.D.P. among trading partners increases the demand for imported goods from China, promoting the growth of China's value-added and total exports. Geographical distance has a negative and statistically significant impact on China's value-added and total exports to its trading partners. Compared to the national standard variables, the influence of trading partners' G.D.P. and geographical distance from China on total exports is greater than that on value-added exports.

This result also shows that compared with the traditional factors that influence bilateral trade, such as G.D.P. and geographical distance, the influence of national standards on China's value-added exports is more significant. Thus, participating in G.V.C.s is vital for China. Improving the national standard system and optimising the scale and structure of national standards will increase China's value-added exports and enhance its position in G.V.C.s.

5.2. Robustness check

Table 5 reports the results of various robustness tests. The specifications in columns (1) and (2) narrow the sample's range of countries and areas, including only the high-income countries listed in The World Bank's (2019) business environment report.[7] We adjust the specifications in columns (3) and (4) using data from 2007 to 2015. Furthermore, using cross-sectional models may lead to heteroscedastic errors. Hence, the simplifications in columns (5) and (6) use Panel Corrected Standard Error (P.C.S.E.) regression to overcome heteroscedasticity and contemporaneity.

The robustness tests indicate that growth in total national standards promotes China's value-added and total exports to high-income countries and areas, with a

Table 5. Robustness check results.

	(1) High-income Value-added export	(2) High-income Total export	(3) 2007–2015 Value-added export	(4) 2007–2015 Total export	(5) PCSE Value-added export	(6) PCSE Total export
Total standards	0.5924*** [0.0575]	0.5398*** [0.0695]				
Mandatory standards			2.7197*** [1.1966]	2.8992*** [1.4636]		
Voluntary standards			−2.1990* [1.1777]	−2.4078* [1.4433]		
Mandatory country-specific standards					2.3166*** [0.5648]	2.3788*** [0.5949]
Voluntary country-specific standards					−2.3632*** [0.7903]	−2.1700*** [0.8284]
Mandatory internationally harmonised standards					2.1877*** [1.0266]	2.5510** [1.0760]
Voluntary internationally harmonised standards					−1.4566 [1.9088]	−2.3676 [2.0008]
GDP	1.0045*** [0.0155]	1.0066*** [0.0184]	0.9555*** [0.0179]	0.9689*** [0.0203]	0.9535*** [0.0041]	0.9676*** [0.0044]
Distance	−0.0781*** [0.1046]	−0.0857*** [0.1126]	−0.1739*** [0.0645]	−0.3164*** [0.0729]	−0.1967*** [0.0169]	−0.3397*** [0.0168]
Check	−0.0473* [0.0725]	−0.0641* [0.0870]	−0.0107* [0.0849]	−0.0493* [0.1034]	−0.0048* [0.0651]	−0.0244* [0.0682]
Country-year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year-sector-fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Country-sector-fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Constant	−24.6589*** [1.1598]	−22.2222*** [1.3644]	−12.9153*** [3.3592]	−10.7882*** [4.1343]	−8.8552 [7.5500]	−3.4399 [7.8773]
Observations	363	363	558	558	682	682
R^2	0.9108	0.8791	0.8856	0.8433	0.8933	0.8512
F	1072.2364	757.9890	605.1050	475.6224		

Note: Standard errors are in brackets. *, ** and *** indicate statistical significance at the 10%, 5% and 1% level, respectively. The F-test results are significant at the 1% level.

greater impact on the former. Compared to voluntary standards, mandatory standards have a stronger influence on value-added and total exports. The effect of mandatory country-specific standards and mandatory internationally harmonised standards on total exports is greater than that of value-added exports. The negative impact of voluntary country-specific standards on total exports is the greatest. The trade inhibition effect of voluntary internationally harmonised standards is smaller and less significant, especially for value-added exports. Overall, the size of the coefficients and significance of the explanatory variables are in line with the baseline regression results, supporting their robustness.

6. Conclusion

The study's conclusions are as follows. First, the growth of national standards promotes China's value-added and total exports, and the standards' trade effect on the former is greater than that on the latter. Second, there are fewer mandatory standards, but they positively affect China's value-added and total exports, while large-scale voluntary standards negatively affect them. The trade effect of mandatory standards is significant. Third, mandatory internationally harmonised standards have a greater trade promotion effect on total exports than value-added exports. Voluntary internationally harmonised standards have a lower trade inhibition effect than voluntary country-specific standards.

This study has three policy implications:

1. Chinese authorities should improve the number of standards and the structure of national standards and increase the effective stock of various standards. The increase in China's national standards positively affects both value-added and total trade; however, the trade effects of different national standards are heterogeneous. The gradual increase in the adequate supply of different national standards supports China's exports.
2. Chinese policymakers should strengthen mandatory and voluntary standards and should promote a statistical analysis and reporting system for their implementation. The release and implementation of a standard do not imply the end of the standardisation process. The implementation effect of voluntary standards, particularly voluntary country-specific standards, should be evaluated by scientific research institutions and improved.
3. Authorities in China and other emerging economies should increase the number and proportion of internationally harmonised national standards. Our results support the trade promotion effect of mandatory internationally harmonised standards, and the impact on China's value-added exports is the most significant. The adoption of international standards, combined with national conditions and the improvement in the number and proportion of mandatory and voluntary national standards, may substantially improve China's position in G.V.C.s.

This study does not discuss whether the impact of standards on these different types of G.V.C.s is heterogeneous. G.V.C.s may be simple or complex, depending on

the number of national border crossings, and they are unrelated to the differences in technology or complexity of actual production processes (The World Bank, 2019). Future research should examine the geographical dimension of the heterogeneous effects of international harmonisation on different types of G.V.C.s, such as Factory North America (N.A.F.T.A. in 1994 greatly facilitated the development of North American value chains), Factory Europe (most of Germany's offshoring and global sourcing takes place within Europe), and Factory Asia (Asian economies increase their association with China) (Baldwin & Okubo, 2019).

Notes

1. Standards provide the direct contact plane on which China can carry out economic and trade exchanges and cooperate and participate in G.V.C.s. National standards are also the basis for the formulation of China's domestic industry standards, local standards, and enterprise standards, and they play a leading role in industry and application.
2. There are 61 countries and one area: Australia, Austria, Belgium, Canada, Chile, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Republic of Korea, Latvia, Lithuania, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States, Argentina, Brazil, Brunei, Bulgaria, Cambodia, Colombia, Costa Rica, Croatia, Cyprus, India, Indonesia, Kazakhstan, Malaysia, Malta, Morocco, Peru, Philippines, Romania, Russia, Saudi Arabia, Singapore, West Africa, Thailand, Tunisia, Vietnam, and Hong Kong (China).
3. The corresponding matching table between ISIC. Rev. 3 and ICS is available from the author.
4. Missing variables include variables that are related to the standards but are difficult to describe with quantities, such as the stringency of the standards, age of the standards, and degree of advancement of the standards.
5. How standards are enforced is crucial. If there is a plethora of standards, but none are enforced, then the standards are largely ineffectual.
6. 6 This is the first attempt to combine the publication of standards and their implementation. Previous studies have focused on the publication of standards (Blind, 2004; Blind et al., 2018; Mangelsdorf et al., 2012). In contrast, this study uses the number of unqualified product announcements of random national inspections published on the C.Q.N. website to measure the enforcement of national standards.
7. There are 32 countries and one area: Australia, Austria, Belgium, Canada, Chile, Czech Republic, Denmark, Finland, France, Germany, Sweden, Iceland, Ireland, Israel, Italy, Japan, Republic of Korea, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, United Kingdom, United States, Cyprus, Malta, Singapore, and Hong Kong (China).

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Data availability statement

Data supporting the findings of this study are available from the corresponding author upon reasonable request.

Disclosure statement

The authors report there are no competing interests to declare.

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