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The Impact of Food Standards on Export Quality in China: the Mediating Effect of TFP

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Despite ample existing research on the trade effect with respect to food standards set by importing countries, the impact of national food standards adopted by exporting countries on firms' productivity and export quality remain ambiguous. Using a firm–level Chinses trade data, this study assesses the relationship between national food standards, total factor productivity (TFP), and export quality by applying a mediation model. Our findings indicate that Chinese national food standards could enhance both firm's TFP and export quality; and TFP partially mediates the relationship between food standards and export quality. Moreover, we distinguish the impact of national food standards according to different standard attributes. In contrast to the mandatory standards, the voluntary standards could significantly stimulate firms' export quality upgrades through improving TFP. Additionally, this study implies the different ownership and exporting destination play a role in determining impacts of national food standards on firms' TFP and export quality in China. The results reveal that the food standards could enhance the firms' export quality through TFP improvement for non–SOEs and high–income exporting destinations.

Key words: export quality, food standards, mediating effect, TFP

INTRODUCTION

Developing countries have long been seen as the international 'standards–takers' in the global market (Swinnen, 2016; Curzi *et al*., 2020). With the substantial reduction in tariffs, World Trade Organization (WTO) members are increasingly implementing non–tariff trade barriers and resorting to non–tariff measures (NTMs) as alternative mechanisms to protect their domestic industries. An importing country's NTMs signify high technological requirements, higher compliance costs, and higher import prices for exporters (Swinnen, 2017; Santeramo and Lamonaca, 2019). Therefore, less developed countries often consider the standards issued by developed countries to be non–tariff trade barriers, due to their limited capacity to meet the requirements of public regulatory standards (Otsuki *et al*., 2001; Wilson and Abiola, 2004; Henson and Jaffee, 2008). For example, sanitary and phytosanitary measures (SPS) have been demonstrated a distortionary effect that significantly inhibits developing countries' food exports (e.g, Winchester *et al*., 2012; Murina and Nicita, 2017).

Under these circumstances, as exporters in developing countries, the food standards or policies formulated by domestic government to emphasize quality, safety, and environmental sustainability may provide the prerequisites and opportunities for them to cope with such non–tariff trade barriers. However, extant studies have predominantly focused on importing countries, the standards implemented by exporting countries, particularly less developed nations are rather rare. In this study, we examine the effect of national food standards set by exporting countries by constructing firm–product level export data from China and discuss whether such legislation and governance on food production could stimulate food traders' production efficiency, thereby improving the export quality. As one of the major players in international food exporters, China could be a suitable case to illustrate these issues. China's agro–food trade has dramatically increased since its participation in the WTO, whereas in the meantime, the recurrence of Chinese food scandals has continuously triggered attention from the international community (Jin *et al*., 2008; Kang, 2019).

To address the food safety issues in China, Chinese authorities has strengthened the food safety governance in the past years. Several government agencies are involved in food safety governance in China, for instance, the Ministry of Agriculture and Rural Affairs, the Food and Drug Administration, Administration of Quality Supervision, Inspection & Quarantine of the People's Republic of China (AQSIQ), and the Standardization Administration of the People's Republic of China (SAC). Particularly, the SAC authorized by the State Council are to exercise administrative responsibilities by undertaking unified management, supervision and overall coordination of standardization work in China, and to be responsible for approving and publishing Chinese standards and adopting international standards, including food standards. As the best practice, those food standards are aimed to be a powerful tool in addressing food quality issues, through reshaping food producers' motivation and actions.

While the effect of standards on trade has long been discussed in existing literature, studies emerging from the perspective of quality upgrading are in an early stage. As a matter of fact, the standards may have

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immediate impact on exported product quality, and consequently impact trade volume. The production of high–quality product has been viewed as a key determinant for the success and directions of export (Amiti and Khandelwal, 2013). From the firm perspective, stringent standards generally may promote effective innovation (Blind, 2016) (or limit investment in technology due to extra compliance costs, so as to benefit or restrict firms' production. However, the influence can be ambiguous depending on which of these two types of effects prevails (Curzi *et al*., 2020).

Chinese national standards are formulated as mandatory standards and voluntary standards according to the different strength of enforcement. Mandatory standards are compulsory for all firms, standardizing all food safety aspects during production processing. The quality of final food products must meet the requirements of mandatory standards before entering the market. Therefore, the increase of mandatory standards number may have a direct promoting effect on export quality. Voluntary standards are optional for firms. Generally, mandatory standards have less stringent restrictions than voluntary standards. A firm taking more voluntary standards implies that the product may have satisfied higher quality standards, giving it an advantage when it comes to exporting, or vice versa. Hence, even the application is not legally binding, voluntary standards may exert pressure on firms in some extent, becoming a commercial imperative or "de facto mandatory standards. As discussed above, are both mandatory and voluntary standards enhancing export quality? Which type of standards would be more effective? On the basis of verifying the impact of aggregate standard, we attempt to answer theses question by further differentiating between the impact of mandatory and voluntary standards.

This study may contribute to the literature in three main ways. First, we use the number of Chinese food standards acting for a proxy for the level of regulatory intensity, to investigate the impact of food standards issued by an exporting country (developing country). Second, by taking TFP as a mediation variable, this study discusses the role of technological improvement and production efficiency in the relationship between standards and export quality upgrades of food firms. Third, we show the different effects of standards on export quality through TFP by identifying different attributes of standards (mandatory vs. voluntary), different firm ownership structures, and various destinations' different income levels.

The remainder of this paper is structured as follows. Section 2 introduces our study hypotheses based on a summary of the relevant literature and an analysis of the relationship between food standards, TFP, and export quality. Section 3 describes our empirical strategy and data collection. Section 4 reports the results and discussion. Section 5 presents the main conclusions and implications.

LITERATURE REVIEW AND HYPOTHESE

Food standards and export quality

Although food standards play a crucial role in the international market for both importing and exporting countries, the effect of regulatory standards remains ambiguous and controversial. Combining the concepts put forward by Aghion *et al*. (2005) and Amiti and Khandelwal (2013), it argued that an increase in competition encourages firms close to the frontier to promote product quality through innovation, making the lagging firms obsolete. The interaction between these two forces arouses a relationship between competition and innovation; thus, inconsistent standards affect quality related to the pro– or anti–competitive effects of standards (Blind and Jungmittag, 2005). Many existing studies have proven that standards have positive effects. To some extent, standards based on scientific evidence, acting as a crucial quality signal in trade, increase transparency and potentially reveal consumer requirements and preferences, so as to boost producers' competitiveness by reducing transaction costs and assisting in resolving the quality degradation caused by information asymmetry in the marketplace (Leland, 1979; Hudson and Jones, 2003).

By contrast, Eum (2018) identified a negative relationship between standards and product quality by analyzing a database of EU imports from 159countries within the period 1995 to 2003..Trade economists have explained the form/number growth of public standards as "a political economy response to the constraints being imposed by international trade agreements on traditional trade restrictions (Swinnen and Vandemoortele, 2011). " NTMs are progressively used to protect domestic industries, and strict regulatory standards lead to export limitations and impose high adaptation costs on producers, thus inhibiting quality enhancement. Moreover, as standards impose high requirements for facility systems and technical knowledge, quality upgrading at smallholder firms has been restrained (Curzi *et al*., 2020).

Hypothesis 1: Food standards are positively/negatively associated with export quality.

Food standards and TFP

TFP is defined as a portion of output not explained by the amount of input in production (such as capital and labor). While the effect of regulatory standards on production efficiency has been extensively examined in the literature on environmental regulation (Zhao *et al*., 2018), research on the relationship between productivity and food standards has not been thoroughly discussed.

Theoretically, food standards may have both a positive and a negative relationship with TFP. On the positive side, there are three potential paths to this influence. First, standards promote firms' TFP by stimulating innovation capability. Strict regulatory standards facilitate innovativeness during the production and design processes, and the benefits of standards on the innovation process outweigh the possible restrictions they impose on innovation (Allen and Sriram, 2000; Shin

et al., 2015). Crafts (2006) suggested that regulation benefits TFP by changing the incentives to innovate and invest. Second, food standards may accelerate firms' TFP by expediting the effects of learning by exporting (LBE). Although many studies have explored reduced market access due to the imposition of strict standards, others have demonstrated that standardization decreases transaction costs and serves as a catalyst for export sectors in developing nations, thus contributing to increased market entry (Tian, 2003; Jaffee and Henson, 2004). The underlying assumption of the LBE effect is certified by the majority of existing evidence: As a consequence of entering foreign markets, firms gain overseas knowledge, which results in improved productivity (Wagner, 2007). Tse *et al*., (2017) opened up the 'black box' of the LBE effect and concluded that innovativeness, production capability, and human capital are the conduits of TFP enhancement. As such, if firms are catalyzed by food standards and increased export opportunities, they may achieve TFP improvement through the LBE effect. Third, to some extent, food standards provide technical specifications for firms that originally lacked production technology, thus speeding up their TFP improvement. Food standards also help to enhance market transparency and create a 'common language' for potential trade partners, thereby reducing extra costs and increasing input in firms' technological innovation.

From a negative perspective, on the one hand, standards implementation could significantly add to the variable costs of producing export products because many standards require quality and/or packaging adjustments (Yang and Otsuki, 2020). Not all firms are equipped to cope with the introduction of strict international standards; food firms have to bear additional compliance costs to keep pace with the changing requirements imposed in standards, and this leads to less investment in productivity improvement. On the other hand, the imposition of standards may be affected by the anti–competitive effect. Standards may boost competition in the market, and the increase in competition reduces firms' innovation budget, moving them further away from the technology frontier and curbing their TFP growth (Aghion *et al*., 2005; Olper *et al*., 2014). Thus, we propose:

Hypothesis 2: Food standards are positively/negatively associated with firms' TFP.

The mediating effect of TFP on food standards and export quality

Previous studies have revealed that food standards affect food firms' export quality and TFP. The following discussion begins with how TFP affects export quality.

First, improved TFP is often denoted as the enhancement of technological progress and innovation capability, so that it incrementally stimulates quality upgrades. Flam and Helpman, (1987) showed that product categories and quality are affected by countries' technology exploitation. Curzi and Olper (2012) showed that firms with higher productivity tend to produce higher quality goods. Therefore, a high TFP firm contributes to promoting export quality upgrades, and vice versa. Second, the impact of firms' TFP on export quality can be interpreted from a cost–benefit perspective. Specifically, under the assumption that labor is the only input in a firm, marginal cost and TFP manifest an inverse relationship, in which lower marginal cost reflects higher TFP. The most productive firms (with low marginal cost) raise quality through competition, whereas less productive firms (with high marginal cost) are hampered in their attempts to raise quality and forced out of the market. Antoniades (2015) clarified this empirical result by predicting a trade model of heterogeneous firms' endogenous quality choices and endogenous markups. Based on these two aspects, firms' TFP may be significantly associated with export quality. Thus, based on the above analysis, we hypothesize the following:

Hypothesis 3: TFP mediates the relationship between food standards and export quality.

METHODOLOGY AND DATA

Model specification

Drawing on Baron and Kenny (1986) and MacKinnon *et al*. (2007) approach to identify the mediating role, this study investigates the mediating role of firms' TFP between food standards and export quality using the causal steps approach. First, we test the total effect of food standards on firms' export quality free of a mediator using Model (1):

$$lnquality_{it} = \alpha_0 + \alpha_1\, lnstd_{it} + \gamma_f Controls_{it} + YearFixedEffects + ProvinceFixedEffects + IndustryFixedEffects + e_1 \quad (1)$$

where i and t stand for food firm i and year t, respectively. $lnquanlity_{it}$ refers to the export quality of firm i in year t. $lnstd_{it}$ represents an indicator of the stock of Chinese national food standards, a proxy for the stringency of the Standards Administration of China's (SAC) regulation on food firms. $Controls_{it}$ includes control variables such as firm age, firm size, trade pattern, firm leverage, capital stock, and foreign direct investment (FDI) to capture and control the variance in firm characteristics. *YearFixedEffects*, *ProvinceFixedEffects*, and *IndustryFixedEffects* stand for the fixed effect at the year level, firms' provincial location, and the 4–digit Chinese Industrial Classification (CIC) code industry level.

Next, we examine the effect of food standards on the proposed mediator TFP as in Model (2):

$$lnTFP_{it} = \beta_0 + \beta_1\, lnstd_{it} + \gamma_f Controls_{it} + YearFixedEffects + ProvinceFixedEffects + IndustryFixedEffects + e_2 \quad (2)$$

Finally, we use Model (3) to determine the mediating effect of TFP on export quality after controlling for

food standards as follows:

$$\begin{aligned} Lnquality_{it} = {} & \theta_0 + \theta_1\, lnstd_{it} + \theta_2\, lnTFP_{it} \\ & + \gamma_f\, Controls_{it} + YearFixedEffects \\ & + ProvinceFixedEffects \\ & + IndustryFixedEffects + e_3 \end{aligned} \tag{3}$$

This model formulation allows us to identify the direct and indirect effects of food standards on export quality and examine the existence of the TFP mechanism (MacKinnon *et al*., 2007).

In the three models above, α_0, β_0, and θ_0 are intercepts, and e_1, e_2, and e_3 represent residuals, respectively. α_1 is the coefficient relating the independent variable (food standards) to the dependent variable (firms' export quality); β_1 is the coefficient relating the independent variable (food standards) to the mediator (TFP); θ_1 is the coefficient relating the independent variable (food standards) to the dependent variable (firms' export quality) adjusted for the mediator (TFP); and θ_2 is the coefficient relating the mediator (TFP) to the dependent variable (firms' export quality) adjusted for the independent variable (food standards). In the above models, the total effect of food standards on firms' export quality is α_1, the direct effect is θ_1, and the indirect effect is $\beta_1{*}\theta_2$ or $(\alpha_1 - \theta_1)$. This step–by–step method to test mediation is widely used in current studies (Otuya, 2019).

Variables and measures

Dependent variable

Our dependent variable is the export quality. According to Amiti and Khandelwal (2013), the quality in this paper is defined as any attribute which raises consumer's demand other than price. That is, according to the utility function (1), given price, increases in the quality measure q_c help to increase demand in country c. Following, Khandelwal *et al*. (2013) and Fan *et al*. (2015) approach, we estimate export product quality as:

$$X_{ijct} = q_{ijct}^{\sigma-1}\; p_{ijct}^{-\sigma}\; P_{ct}^{\sigma-1}\; Y_{ct} \tag{4}$$

where x_{ijct} and q_{ijct} denote the demand and quality of the product that has been exported by firm i to destination country c in year t, respectively. p_{ijct} denotes the export price of the product in industry j exported by firm i to destination country c in year t. P_{ct} and Y_{ct} are the price index and total income of destination country c in year t, respectively. σ is the elasticity of substitution across different products.

In logarithmic form, export product quality can be estimated as the residual from the following ordinary least squares (OLS) regression (Deng *et al*., 2021)

$$\ln(x_{ijct}) + \sigma \ln(p_{ijct}) = \phi_j + \phi_{ct} + \varepsilon_{ijct} \tag{5}$$

where ϕ_j denotes the product fixed effect to capture the differences in prices and quantities across product categories due to the products' inherent characteristics; ϕ_c denotes the country–year fixed effect that collects both the destination price index P_{ct} and income Y_{ct}; and ε_{ijct} is the error term; the elasticity of substitution (σ) is drawn from the estimates of Broda *et al*. (2017).

Given the value of the elasticity of substitution σ in Khandelwal *et al*. (2013), we can estimate quality using Eq. (4). The estimated quality can then be calculated as $\hat{q}_{ijct} = \varepsilon_{ijct}/(\sigma-1)$.

Independent variable

Drawing from Mangelsdorf *et al*. (2012) and Wang *et al*. (2017), we calculate the number of standards to represent a proxy for the level of regulatory intensity in China. First, by given the Concordance table between harmonized commodity description (HS) and International Classification of Standards (ICS) in Wang *et al*. (2017), we calculate the number of standards for each product category as:

$$std_{kt} = std_{kt-1} + execute_{kt} - withdrawn_{kt} \tag{6}$$

where std_{kt} refers to the total number of effective food standards for exported product k in year t; std_{kt-1} is the initial stock of food standards for product k in year t; $execute_{kt}$ is the number of newly published standards for product k in year t; and $withdrawn_{kt}$ is the number of withdrawn standards for product k in year t.

As above, the standards for each product category are different. To construct the national food standards at the firm–level, we initially identify the categories of products produced by each firm; and the total number of standards taken by each firm is calculated by adding up the number of effective food standards for different product categories in the firm. We take the logarithm of the number as a proxy for the regulatory stringency of the national standards on food firms, implying that the more standards a food firm has to comply with during their production process, the higher the regulatory stringency of national standards on food firms.

Mediator

To address the simultaneity bias and selection bias, we employed a semi–parametric approach proposed by Olley and Pakes (1996) (hereafter referred to as OP), we estimated firm–level TFP using a Cobb–Douglas production function:

$$\begin{aligned} \ln Y_{it} = {} & \beta_0 + \beta_1 \ln K_{it} + \beta_2 \ln L_{it} + \beta_3 age_{it} + \sum_m \delta_m year_m \\ & + \sum\nolimits_n \theta_n reg_n + \sum\nolimits_k \phi_k sub_k + exit + \varepsilon_{it} \end{aligned} \tag{7}$$

where Y_{it}, K_{it} and L_{it} refer to total output, capital, and labor inputs of firm i in year t. The age_{it} is the age of firm i. $year_m$, reg_n, and sub_k are set for a series of dummy variables for year, region, and industry, respectively. *exit* represents the exit variable, which is generated based on whether the firm exists in the database. As in most studies in the literature, we use the deflation of firms' output value and capital input by industry–level producer and fixed assets investment (base year is 2000) due to lacking detailed data of firm–level prices or

physical outputs.

Control variable selection

Following existing evidence, this study sets up a vector of control variables representing firm characteristics that may affect food exporters' product quality: (1) *age*. firms' age could affect quality along two opposite paths. On the one hand, Love *et al*. (2016) mentioned that the more mature a firm is, the more experienced its employees are and the better the firm's adaptability. On the other hand, older firms are less motivated to engage in technological development, change, and reformation, which hinders their product quality improvement (Huergo (2006) (2) *size*. As He and Tian (2013) argued, generally, larger firms may have more innovation resources and frequent research and development (R&D) activities. These food firms can subsequently improve the quality of their exported products (Williams, 2011). (3) *trade*. Wang and Wei (2010) pointed out that processing exports may be of higher quality than normal trade export products because higher quality intermediate inputs are used for manufacturing. Hence, we construct a dummy variable of trade pattern for a control variable. (4) *leverage*. It is not easy for a highly leveraged firm to allocate ample funds to supporting product development. As Matsa (2011) discussed, highly leveraged firms seem to depress the quality of their products in order to preserve fund flow for debt service. (5) *capital*. we further control capital stock because firms with substantial capital are more able to conduct innovation activities, thus promoting product quality renewal. (6) *fdi*. FDI contributes to obvious aggrandizement in the export quality of Chinese products. As Jin *et al*. (2017) discussed, an increase in free trade agreements boosts domestic firms' investment in R&D and new technology applications. Additionally, we set up dummy variables for the CIC 3–digit industries, regions, and years to control for the unobservable industry, firm location, and time–specific factors that may be correlated with export quality, TFP, and standards.

Data description

The dataset presented in this study was constructed by combining firm–level export data on Chinese food industry firms for the period 2000–2013. The first data source is the Annual Survey of Industrial Enterprises (ASIE), which is maintained by China's National Bureau of Statistics (NBS). This dataset provides detailed operating information (e.g., employment, sale value, output, fixed assets, value added, ownership structure) about all state–owned manufacturing firms as well as non–state–owned manufacturing firms with sales over RMB 5million Chinese yuan. Further, we cleaned the data set following Brandt *et al*. (2012).

The second data source applied in this study is the China Customs Database. This database includes detailed information about imports and exports of all firms' 8–digit HS products, including product code, product unit, export quantity, value, ownership of firms, export destination, and type of trade (e.g., processing trade or ordinary trade). The HS changes from HS 1996 to HS 2002 during the sample period, which does not allow us to convert the HS 8–digit level between the two versions. Thus, we aggregate export values and export quantity by the HS 6–digit level and then compute the export unit price. Furthermore, to address the noise in the sample, we drop the firm data in cases where (1) the export quantity is less than or equal to 1 and the trade volume is less than $50 per transaction, and (2) information such as company name, export destination, or product code is missing.

The third data source is from SAC National Standards Query (http://std.samr.gov.cn/gb/gbQuery). This dataset provides information about Chinese standards, including food standards and the date a standard took effect or was withdrawn or replaced by a new version. The product identifiers in the SAC query system are classified by the International Classification for Standards (ICS), which makes it possible to match standards to customs data. Mangelsdorf *et al*. (2012) demonstrated the completeness and reliability of this database. This dataset allows differentiating between mandatory and voluntary standards: the prefix 'GB' indicates mandatory standards and voluntary standards are prefixed 'GB/T'. For instance, the standard GB/T 27643–2011 is voluntary standards for meat and meat products; the standard GB 10138–2005 is mandatory standard for fish and aquatic products. The examples of standards are shown in Table 1.

Following Mangelsdorf *et al*. (2012), Wang *et al*. (2017) provided more detailed the correspondence between ICS categories and HS codes, making the prod-

Table 1. Examples of Chinese food standards

Product	Standard code	Name of standard	Type of standard	ICS
Meat and meat products	GB/T 27643–2011	Hazard analysis and critical point (HACCP) for application to quick–frozen foods	Voluntary	67.120.10
Meat and meat products	GB 19088–2003	Product of designations of origin or geographical indication—Jinhua ham	Mandatory	67.120.10
Fish and aquatic products	GB/T 27624–2011	Manufacturing practice for processing of fresh and frozen cultured Takifugu rubripes	Voluntary	67.120.30
Fish and aquatic products	GB 10138–2005	Hygienic standard for salted fish	Mandatory	67.120.30

Source: The SAC National Standards Query: http://std.samr.gov.cn/gb/gbQuery

Table 2. Correspondence table between HS and ICS

Product categories	ICS	HS code
Meat and meat products	67.120.10;67.120.20; 67.120.9;67.120.21	01,02,04.07–04.10, 05,16.01–16.02
Fish and aquatic products	67.120.30	03,16.03–16.05
Milk and dairy products	67.100	04.01–04.06
Fruits, vegetables, and related products	67.080	07,08,20
Tea, coffee, and cocoa	67.140	09,18
Grains	67.060	10,11,19
Animal and vegetable oils	67.200	15
Sugar and sugar products	67.180,67.190	17
Spices and condiments, food additives	67.220	21
Beverages, wine, and vinegar	67160	22

Source: Wang *et al.* (2017)

Table 3. Definition of variables and summary statistics

Variable	Definition	Mean	Std. dev	Min.	Max.
quality	Export quality estimation approach by Khandelwal, Schott & Wei.. (2013)	0.5191	0.3908	0.0000	1.0000
std	Logarithm of the number of aggregated food standards	4.5871	0.7607	1.9459	6.9508
mstd	Logarithm of the number of mandatory food standards	2.8711	1.1647	0.0000	5.6168
vstd	Logarithm of the number of voluntary food standards	4.2424	0.7867	1.7918	6.6846
tfp	Logarithm of TFP calculated using the Olley and Pakes (1996) approach	4.7799	1.0563	–2.0843	9.6911
age	Current year – year of establishment + 1	10.2091	7.0078	0.0000	64.0000
size	Logarithm of number of employees	5.2065	1.1349	2.0794	10.9219
trade	Dummy variable for trade pattern = 1 if the firm's pattern is processing trade	0.2125	0.4091	0.0000	1.0000
leverage	Ratio of total liability to total assets	0.5694	0.3146	0.0220	1.7950
capital	Logarithm of capital stock	9.1562	1.7034	–0.3221	15.7342
fdi	Dummy variable for FDI = 1 if the firm's FDI ratio is more than 0% (FDI ratio = foreign capital/total capital)	0.5222	0.4995	0.0000	1.0000

Note: To eliminate the influence of outliers in the models, all continuous variables are winsorized at both the top and bottom 1% (e.g., Deng *et al*., 2021).

uct types in this databases match with those in the customs data. Thus we use the concordant method to construct standard indicators. A concordance table between ICS categories and HS codes compiled by Wang *et al.* (2017) can be seen in Table 2.

As mentioned above, we merge three datasets to construct a product–firm–year–destination level data. The definitions of the relevant variables and summary statistics are presented in Table 3.

RESULTS AND DISCUSSION

The correlation matrix for the dependent and independent variables are presented in Table 4. The correlation matrix shows that multicollinearity does not appear to be a concern in explaining the results of the variance inflation factor (VIF).

Basic results

Table 5 reports the regression results based on Models (1)–(3). After controlling a set of potential influencing factors in Model (1), the coefficient of *std* in Model 1 is 0.0161 at the significance level of 1%, indicating that food standards could significantly enhance firms' export quality. This result is in line with Olper *et al.* (2014) finding. Hypothesis 1 is supported. Model (2) revealed that the national food standards could significantly simulate firms' TFP improvement, verifying Hypothesis 2. The coefficients of food standards and TFP in Model (3) are significant at the 1% level, which further showed that TFP partially mediated the relationship between food standards and exported quality, supporting our hypothesis 3. Analysis of the intermediary effect present in Models (1)–(3) shows that the total effect of food standards on export quality is α_1= 0.0161, the direct effect is θ_1=0.0156, and the indirect effect of

Table 4. Correlation matrix

	quality	*std*	*tfp*	*age*	*size*	*trade*	*leverage*	*capital*	*fdi*
quality	1.0000								
std	–0.0041	1.0000							
tfp	0.0180***	–0.0986***	1.0000						
age	0.0314***	0.1227***	–0.0099	1.0000					
size	0.0367***	0.0917***	–0.0262***	0.2759***	1.0000				
trade	0.0257***	0.0019	0.0173***	0.0493***	0.0845***	1.0000			
leverage	0.0052	–0.0781***	0.0558***	0.0204***	–0.0085	–0.0096	1.0000		
capital	0.0199***	0.1285***	–0.1705***	0.2234***	0.5822***	0.0545***	–0.1040***	1.0000	
fdi	0.0119*	0.0737***	–0.0926***	–0.0780***	–0.1120***	0.0235***	–0.0066	–0.0271***	1.0000
VIF		1.05	1.05	1.11	1.61	1.01	1.02	1.61	1.03

Note: This table presents the main variables' correlation coefficients and variance inflation factor. The sample includes firm–year observations for the period 2000–2013. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 5. Whole sample regression results

Variable	Model (1) *quality*	Model (2) *tfp*	Model (3) *quality*
std	0.0161*** (0.0040)	0.0641*** (0.0084)	0.0156*** (0.0040)
tfp			0.0076*** (0.0027)
age	0.0013*** (0.0004)	0.0080*** (0.0011)	0.0013*** (0.0004)
size	0.0069** (0.0029)	–0.0699*** (0.0066)	0.0063** (0.0029)
trade	0.0167*** (0.0062)	0.0293*** (0.0101)	0.0165*** (0.0062)
leverage	–0.0005 (0.0083)	–0.0134 (0.0193)	–0.0004 (0.0083)
capital	–0.0006 (0.0019)	–0.1445*** (0.0047)	0.0004 (0.0019)
fdi	0.0139** (0.0054)	–0.0645*** (0.0136)	0.0150*** (0.0054)
Constant	0.4020*** (0.0326)	6.5869*** (0.0872)	0.3561*** (0.0365)
Number of firms	9731	9731	9731
R–Squared	0.0117	0.2051	0.0120

Note: (1) Standard errors are reported in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively. (2) All regressions include the CIC 3–digit level industry fixed effects, region fixed effects, and year fixed effects.

food standards on export quality through enhancing firms' TFP is 0.0005 (the mediating effect of TFP is β_1*θ_2, that is, 0.0641*0.0076).

Results of mandatory standards and voluntary standards

To observe different impacts brought by mandatory and voluntary standards, we further use two types of standards as independent variables to run mediation models (1)–(3). The results are listed in Table 6.

The results reveal differently between mandatory and voluntary standards. For mandatory standards, the Model (1) results show a significant positive relationship with export quality, which is in line with the findings in Wang *et al*. (2017), who observed mandatory standards improve Chinese agricultural product quality. In the Model (2), mandatory standards show a non–significant relationship with TFP, indicating that TFP does not mediate the relationship between mandatory standards and firms' export quality. With regard to voluntary standards, the Model (1) and (2) results indicate that voluntary standards exert positive effects on both export quality (coef. 0.0115, $p < 0.01$) and TFP (coef. 0.1046, $p < 0.01$). The Model (3) results further show that voluntary standards could enhance export quality through TFP improvement. This result reveals that voluntary standards can improve the quality of exported food products by stimulating improvements in technological innovation and production efficiency. It supports the findings of recent studies such as Fouilleux and Loconto (2017), who found that the adoption of voluntary standards acts as a crucial economic and institutional incentive for food exporters to produce safe, high–quality products, as well as the integration of these products into the global food system.

Results of ownership differences

As Tse *et al*. (2017) suggested, state–owned and non–state–owned firms face significant institutional differences in China. State–owned enterprises (SOEs) are inclined to prioritize other goals (such as maintaining social stability, decreasing unemployment, and stabilizing taxation), rather than optimizing production efficiency, technological capabilities, and innovativeness. Moreover, it has been suggested that SOEs approach 'innovation' as a management strategy to derive benefits from the policies, rather than to improve their technological competitiveness (Wei *et al*., 2020). Therefore, we further investigate the differential impacts of food standards on export quality through TFP for SOEs versus

Table 6. Regression results: mandatory vs. voluntary standards

Variable	Mandatory			Voluntary		
	Model (1)	Model (2)	Model (3)	Model (1)	Model (2)	Model (3)
	quality	*tfp*	*quality*	*quality*	*tfp*	*quality*
mstd	0.0101*** (0.0025)	0.0015 (0.0050)	0.0102*** (0.0025)			
vstd				0.0115*** (0.0042)	0.1046*** (0.0087)	0.0105** (0.0042)
tfp			0.0032 (0.0028)			0.0074*** (0.0027)
Firm controls	YES	YES	YES	YES	YES	YES
Constant	0.4428*** (0.0304)	6.4981*** (0.0790)	0.4240*** (0.0347)	0.4224*** (0.0328)	6.4185*** (0.0872)	0.3798*** (0.0364)
Number of firms	9731	9731	9731	9731	9731	9731
R–squared	0.0147	0.2811	0.0147	0.0113	0.2112	0.0116

Note: (1) Standard errors are reported in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively. (2) All regressions include the CIC 3–digit level industry fixed effects, region fixed effects, and year fixed effects.

Table 7. Regression results: SOEs vs. non–SOEs

Variables	SOEs			Non–SOEs		
	Model (1)	Model (2)	Model (3)	Model (1)	Model (2)	Model (3)
	quality	*tfp*	*quality*	*quality*	*tfp*	*quality*
std	–0.0093 (0.0265)	0.0532 (0.0666)	–0.0111 (0.0265)	0.0161*** (0.0041)	0.0573*** (0.0084)	0.0158*** (0.0041)
tfp			0.0333** (0.0147)			0.0063** (0.0028)
age	–0.0011 (0.0011)	–0.0079** (0.0033)	–0.0006 (0.0011)	0.0017*** (0.0004)	0.0137*** (0.0012)	0.0016*** (0.0004)
size	0.0000 (0.0177)	0.1265*** (0.0486)	–0.0060 (0.0178)	0.0066** (0.0029)	–0.0786*** (0.0066)	0.0063** (0.0029)
trade	0.0217 (0.0409)	0.1189 (0.0804)	0.0150 (0.0408)	0.0161*** (0.0062)	0.0254** (0.0102)	0.0161** (0.0062)
leverage	0.0079 (0.0433)	–0.5826*** (0.1228)	0.0309 (0.0443)	–0.0001 (0.0085)	0.0248 (0.0195)	–0.0004 (0.0085)
capital	–0.0007 (0.0124)	–0.1063*** (0.0363)	0.0032 (0.0125)	–0.0004 (0.0019)	–0.1432*** (0.0047)	0.0004 (0.0020)
fdi	–0.0124 (0.0354)	0.1099 (0.1121)	–0.0201 (0.0355)	0.0137** (0.0055)	–0.0782*** (0.0136)	0.0148*** (0.0055)
Constant	0.5153*** (0.1675)	4.6142*** (0.5204)	0.3429* (0.1834)	0.4066*** (0.0336)	6.6503*** (0.0881)	0.3679*** (0.0377)
Number of firms	416	416	416	9,490	9,490	9,490
R–squared	0.0348	0.2436	0.0418	0.0121	0.2144	0.0123

Note: (1) SOE refers to the state–owned enterprise; Non–SOE refers to the non–state–owned enterprise. (2) Standard errors are reported in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively. (3) All regressions include the CIC 3–digit level industry fixed effects, region fixed effects, and year fixed effects.

non–SOEs. The regression results are presented in Table 7.

Table 7 describes the result for differences in ownership structure. The results show that for SOEs, food standards do not have significant effects on export quality and TFP. The results fail to satisfy the conditions for a mediation effect (Baron and Kenny, 1986). Yet, the coefficients are significantly positive in the Model (1)–(3) for non–SOEs, implying an obvious mediation effect of TFP between national food standards and export quality in the Chinese food sector. This finding is in line with the previous discussion. Compared to SOEs, non–SOEs are more likely to exhibit market adaptability, optimize resource allocation, and enhance production capa-

bility and operational efficiency as they are more motivated and competent (Tan and Peng, 2003).

Results of destination differences

Drawing from the literature related to export destinations, there is an underlying viewpoint that the decisions made by producers in exporting countries could be affected by the importing countries' varying features (Melitz and Redding, 2012). In recent literature, some evidence indicates that richer, more developed destinations affect firms' behavior: Firms that export to high–income countries are apt to pay higher average wages, hire more skilled workers, and aim for better skill utilization, as well as value high product quality (Brambilla and Porto, 2016). Therefore, the impact of food standards on export quality and firms' TFP can be heterogeneous, depending on export destinations' features. To identify the different effects of food standards on food exporters as affected by importing country differences, this study divides the samples into high–income and middle– and low–income destinations, according to destination country income levels as classified in the World Development Indicators (WDI) database.

Table 8 shows the regression results for the differences in destination countries. In the results of model (1)–(3) for high–income destinations, the national food standards could improve export quality (coef. 0.0164, $p < 0.1$) and TFP (coef. 0.0606, $p < 0.1$); TFP play a mediating role in the relationship between food standards and export quality. In contrast, the impact of national food standards and TFP on export quality corresponding to middle– and low–income exporting countries are not significant.

CONCLUSION AND POLICY IMPLICATION

Despite ample research on the trade effect with respect to international food standards, the economic effect of national food standards on firms' production efficiency and quality remains nearly unexamined. Based on firm–level census data from 2000–2013 and Chinese national standards query data promulgated by the SAC, this study conceptualizes the impact of food standards on export quality through the mechanism of TFP and conducts an empirical study on the relationship between food standards, firms' TFP, and export quality by applying a mediation model.

The results show that the Chinese national food

Table 8. Regression results: income differences among destination countries

	High income			Middle and low income		
	Model (1)	Model (2)	Model (3)	Model (1)	Model (2)	Model (3)
Variables	*quality*	*tfp*	*quality*	*quality*	*tfp*	*quality*
std	0.0164***	0.0606***	0.0159***	–0.0071	0.0562	–0.0073
	(0.0042)	(0.0088)	(0.0042)	(0.0155)	(0.0351)	(0.0155)
tfp			0.0079***			0.0107
			(0.0028)			(0.0099)
age	0.0013***	0.0086***	0.0013***	0.0008	–0.0014	0.0008
	(0.0004)	(0.0012)	(0.0004)	(0.0013)	(0.0030)	(0.0013)
size	0.0072**	–0.0611***	0.0067**	0.0072	–0.0173	0.0066
	(0.0030)	(0.0069)	(0.0030)	(0.0105)	(0.0233)	(0.0105)
trade	0.0117*	0.0296***	0.0114*	0.0581***	–0.0294	0.0586***
	(0.0064)	(0.0107)	(0.0064)	(0.0224)	(0.0408)	(0.0224)
leverage	–0.0013	–0.0094	–0.0012	0.0281	0.0153	0.0274
	(0.0086)	(0.0202)	(0.0086)	(0.0299)	(0.0651)	(0.0299)
capital	–0.0003	–0.1467***	0.0008	0.0010	–0.1174***	0.0021
	(0.0020)	(0.0049)	(0.0020)	(0.0065)	(0.0146)	(0.0066)
fdi	0.0150***	–0.0698***	0.0162***	–0.0060	0.1208***	–0.0068
	(0.0056)	(0.0142)	(0.0057)	(0.0201)	(0.0463)	(0.0202)
Constant	0.3879***	6.6010***	0.3400***	0.5173***	5.9993***	0.4552***
	(0.0345)	(0.0926)	(0.0386)	(0.1060)	(0.2540)	(0.1207)
Number of firms	9,255	9,255	9,255	1,509	1,509	1,509
R–squared	0.0124	0.2082	0.0127	0.0283	0.3132	0.0289

Note: (1) Countries'/economies' income group classifications are sourced from the World Development Indicators (WDI) database: https://datahelpdesk.worldbank.org/. The high–income group in this table refers to high–income countries classified in the WDI database, whereas the middle– and low–income groups in this table refer to the following country groups taken from the WDI database: i) upper middle income, ii) lower middle income, and iii) low income. (2) Standard errors are reported in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively. (3) All regressions include the CIC 3–digit level industry fixed effects, region fixed effects, and year fixed effects.

standards positively impact firms' TFP and export quality; and TFP partially mediated the relationship between the food standards and exported quality. Subsequently, the impact of food standards on firms differs in the presence of mandatory versus voluntary standards. Mandatory standards exert non–significant impact on firms' TFP and export quality, whereas the voluntary standards reveal a remarkable stimulating effect on export quality through TFP improvement. In addition, we also carry out a heterogeneous analysis based on ownership and destination differences. We find that non–SOEs demonstrate a significant stimulus effect of food standards on firms' export quality through the mediation mechanism of TFP improvement, while SOEs did not show any significant effect of the standards on firms' export quality through the mediating role of TFP. Moreover, the national food standards obviously enhanced the firms' export quality through TFP for high–income destinations; the impact of national food standards and TFP on export quality corresponding to middle– and low–income exporting countries are not significant.

The empirical findings of this study highlight the following implications for policymakers in China, as well as for developing country authorities involved in food standards or related policy formulation. First, our results illustrate that national food standards can improve product quality by increasing firms' TFP. China and other less developed countries should increase their efforts to strengthen and optimize the promulgation and utilization of national–level food standards/policies. Providing domestic firms with good technical specifications and quality inspection criteria in order to minimize trade losses caused by international standards from importing countries is also recommended. Second, due to the different impacts emerging from mandatory versus voluntary standards, Chinese authorities should increase voluntary standards and set up incentive mechanisms to encourage food exporters to adopt suitable standards on their own initiative, so as to effectively mitigate the cost pressure mandatory standards exert on firms. Third, according to our findings on the heterogeneous effect of food standards on SOEs and non–SOEs, the government should strengthen its supervision of SOEs' operations, and appropriate reward and punishment mechanisms should be adopted in SOEs to facilitate their learning efficiency. Finally, policymakers in emerging economies should expand their ISO participation and contribute to harmonizing purely domestic standards with international standards in order to enhance firms' competitiveness in the developed market.

It is important to state that though this study attempt to focus on providing evidence of a causal claim, the obtained relations are in the most cautious way mere correlations. As for the estimation strategy, though several elements such as control variables and fixed effects are established in order to rule out problematic issues such as cofounding elements in the empirical estimation, it is not possible to make causal claims without additional examination of the results. First, more productive firms will obviously have higher TFP and be more likely to apply standards and achieve higher quality. This will cause the estimated coefficient to be larger than in the case of standards that were randomly distributed across firms. Second, the time–varying unobservable heterogeneity bias caused by uncertain shocks to a firm at some point in time could affect the estimated coefficients upwards or downwards. Third, some omitted, unobservable variables might make bias the coefficients on the number of food standards. Moreover, the method of TFP estimation may suffer from functional dependence problems, similarities in the environments that different firms face, what variables are in firms' information sets when different inputs are chosen, and limiting the amount of unobserved heterogeneity in production functions across firms (Ackerberg *et al.*, 2015). Future study would discuss several causality issues between standards, productivity and export quality, and address the potential bias of the estimation, through applying robust method and provide several robustness checks. In addition, although this study distinguishes the impact of mandatory and voluntary standards, we did not identify the contribution of the standards for these two different attributes in the heterogeneity analysis, further study could contribute to the literature by investigating further differences in stringency of standards in different countries by showing the results by standard type and destination market.

AUTHOR CONTRIBUTIONS

All authors have discussed the results and contributed to the final manuscript. Mi Jie suggested the original idea, performed empirical computations, and drafted the manuscript. Nanseki Teruaki designed the research framework, advised on data interpretation, and edited the manuscript.

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