frontiers | Frontiers in Environmental Science

ORIGINAL RESEARCH
published: 27 May 2022
doi: 10.3389/fenvs.2022.892632

Does Geographical Indication Certification Increase the Technical Complexity of Export Agricultural Products?

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As a special intellectual property right, geographical indications have obvious regional quality signals and reputation. Whether geographical indication certification can promote the technical complexity of export agricultural products in the process of high-quality agricultural transformation in developing countries is a new issue that has to be studied urgently. Therefore, based on the provincial panel data from 2005 to 2019, this research examines the impact of geographical indication certification on the technical complexity of China's export agricultural products. The empirical results reveal that geographic indication certification can significantly improve the technical complexity of export agricultural products. Moreover, the positive spillover effect of geographical indications on the export of agricultural products is strengthened as the level of the technical complexity of products increases. However, the regression coefficient at the 85% quantile decreases, reflecting that the current international recognition of geographical indication certification in China needs improvement. The heterogeneity study finds that the above results are not significantly supported by evidence in the central region. Thus, the quality guidance role of geographical indication products in the central region has not been brought into full play, thereby restraining the price addition ability of export agricultural products. Therefore, the government should increase policy support to enhance the quality guidance role of geographical indication products.

Keywords: Agricultural products (APs), export, technical complexity, Geographical Indication (GI), green innovation ability

Edited by:
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Specialty section:
This article was submitted to Environmental Economics and Management, a section of the journal Frontiers in Environmental Science

Received: *09 March 2022*
Accepted: *04 April 2022*
Published: *27 May 2022*

Citation:
Xu Z, Feng Y and Wei H (2022) Does Geographical Indication Certification Increase the Technical Complexity of Export Agricultural Products? Front. Environ. Sci. 10:892632. doi: 10.3389/fenvs.2022.892632

1 INTRODUCTION

The global consumption upgrade makes people pay more attention to food safety. However, the long-term extensive economic and trade growth model of developing countries makes them face a conflict between insufficient effective supply and low-end oversupply (Ma et al., 2021). Moreover, asymmetric information often forces consumers to make choices based on the average quality perceived by the market. Therefore, it is difficult for some export agricultural products to obtain sufficient quality premium in the process of quality upgrading.

Under this background, (GI) products that use product quality, reputation, or other characteristics to determine the origin of the products are attracting more and more attention (Josling, 2006). GI certification (GIC) of agricultural products has become an effective method to identify consumers' quality (Rytkö nen et al., 2018; Grebitus et al., 2011; Raimondi et al., 2020; Chalupová et al., 2021).

The standardization of GIs in China started late. In the past decade, the scandals of GI agricultural products have been frequent, which has revealed that the certification of GI does not play a significant role in upgrading the export quality of agricultural products (Tam and Yang, 2005; Ross and Cai, 2008). Therefore, how to resolve the trust crisis of international consumers and improve the technical complexity of export agricultural products is a key problem that should be solved urgently in the rapidly growing developing countries.

There is no consensus on the influence of GIC on export quality. Trademarks and brands have the attributes of decentralized management and homogenization of products. Therefore, the short-term role of quality guidance is difficult for such forms of intellectual property protection (Josling, 2006). Under a condition of asymmetric information, consumers find it difficult to obtain reliable information through trademarks or brands (Akerlof, 1970; Marette and Crespi, 2003; Chilla et al., 2020); thus, they often base on the average quality perceived by the market to make consumption choices (Winfree and McCluskey, 2005; Moschini et al., 2008), which inhibit the enthusiasm of producers to upgrade their quality. By contrast, attaching geographical labels to products with trademarks and brands can link the quality attributes of products to specific geographical sources. On the one hand, it enhances the quality guidance for consumers (Moschini et al., 2008; Brentari et al., 2011; Menapace and Moschini., 2012; Jarma Arroyo et al., 2020). On the other hand, it largely eliminates the competition of products from unspecified geographical sources (Codron et al., 2005). Under open conditions, it plays an important role in promoting the export scale and quality of agricultural products (Agostino and Trivieri, 2014; Chilla et al., 2020; Török et al., 2020). However, this result does not only depend on the relatively strict and effective supervision system (Anania and Nisty`o, 2004; Langinier and Babcock, 2008). Otherwise, it will not be able to prevent the market competition of "counterfeit" products, which will have a crowding-out effect on GI products (Yuanhua et al., 2016). It also depends on whether governments are willing to make concerted efforts for GIC (Agostino and Trivieri, 2014; De Rosa, 2015). Due to the differences in geographic information systems among countries, it may be used as a trade barrier against competition (Marette et al., 2008). Some studies believe that GIs have the attribute of "public goods" (Menapace and Moschini., 2012), implying that similar geographical products with no obvious product differences cannot be excluded from low-cost imitation, leading to fierce market competition (Lence et al., 2007; Mulik and Crespi, 2011).

The following paragraphs discuss China's situation. Most studies have focused on the economic impact of GI products on producer incentives (Bramley and Bienabe, 2012; Dogan and Gokovali, 2012; Zhao et al., 2014; Zhao et al., 2016; John et al., 2020) and economic welfare (Kireeva and Vergano, 2006; Xiaobing and Kireeva, 2007; Bramley et al., 2009; Lee et al., 2020) under closed conditions. Empirical discussion on the export of GI products is relatively scarce. The research mainly focuses on intellectual property laws and regulations of GIs (Josling, 2006; Bramley and Bienabe, 2012). For example, Bramley (2011) reviewed the relevant literature on the impact of GIC on the social economy of developing countries and found that, as a quality reputation indicator, GIC can significantly improve the quality of agricultural products, thus helping to improve the economic benefits of a country. However, the certification system of GIs brings challenges to developing countries. Standards that are too high or not strictly enforced can have a negative impact. Evidence from environmental economics demonstrates that financial development, resource endowment, globalization, foreign direct investment (FDI), and other factors will affect a country's economic growth by influencing its environmental performance and have an uncertain effect on the upgrading of export quality (Roth et al., 2008; Bin and Jiangyong, 2009; Yang et al., 2021; Rehman et al., 2021; Usman and Jahanger, 2021; Fareed et al., 2022). However, research rarely examines the effect of GIs on the technical complexity of China's agricultural exports.

The contributions of this study are as follows. First, this is a novel study to discuss the influence of GI products on the technical complexity of the export of agricultural products. Second, this study enriches the literature on the influence of GIs on the quality and reputation of export products. Finally, this study provides a more accurate identification method of GIs and a more microscopic analysis. Compared with the previous process of using dummy variables, this study uses the cumulative quantity of GI products in different regions of China as the proxy variable for GI agricultural products. This method can more accurately measure GI among provinces and overcome possible measurement errors. Moreover, this study deeply discusses the internal heterogeneity of GIC's influence on export quality based on provincial microdata.

2 MODEL AND DATA

2.1 Model

Recent relevant research reveals that the human resource endowment, agricultural added value, degree of opening to the outside world, degree of networking, FDI, and R&D capability of each region will affect the technical complexity of export agricultural products. Therefore, this study uses provincial-level data to build a fixed-effect panel data model. It also discusses the influence of GIC on the technical complexity of export agricultural products. The specific model is set as follows:

$$\ln TSI_{it} = \alpha + \beta_0 \ln GI_{it} + \beta_1 X_{it} + \delta_i + \eta_t + \varepsilon_{it} \quad (1)$$

where i and t represent provinces and years, respectively; $TSI_{i,t}$ represents the technical complexity of export agricultural products; $GI_{i,t}$ represents the certification of GIs; δ_i and η_t represent the fixed effects of provinces and years, respectively, and $\varepsilon_{i,t}$ represents the random error term.

This study also uses the quantile regression method to discuss the ladder effect of GIC on the technical complexity of exporting different agricultural products. The Probit binary discrete regression model is used for the robustness test, and 2SLS (two stage least squares) and GMM (Generalized method of moments) methods are used for the endogenous test. To ensure the effectiveness of tool variable selection, this study verifies the rationality of tool variable selection using the LM (Lagrange multiplier) Test and Wald F test (Kleibergen and Paap, 2006).

2.2 Data and Variable

2.2.1 Export Technology Complexity (TSI)

Based on the extension method of Hausmann et al. (2007), Xu and Lu (2007), this study constructs the export technology complexity index at the province level. First, the technical complexity of export agricultural products is measured at the product level:

$$PRODY_{kt} = \sum_{i} \frac{(x_{ikt}/X_{it})}{\sum_{k}(x_{ikt}/X_{it})} \cdot Y_{it} \tag{2}$$

where k represents an HS-6 code product; i represents a province; $x_{i,t}$ represents the export volume of province i's product k, and X_i represents the total export volume of a province. $x_{i,k,t}/X_{i,t}$ represents the proportion of exports of province i's product k to the province's total exports, and $Y_{i,t}$ represents the actual per capita GDP of province i.

We calculate the technical complexity of export agricultural products at the provincial level as follows:

$$TSI_{it} = \sum_{i} \frac{x_{ikt}}{\sum_{k} x_{ikt}} PRODY_{kt} \tag{3}$$

where $TSI_{i,t}$ is the technical complexity of export agricultural products of province i, and $x_{i,k,t}/\sum x_{i,k,t}$ represents the proportion of the export of product k of province i to the total export of the province.

2.2.2 Geographical Indication Certification (GIC)

GI is measured in two ways in the existing literature. One is measuring GI products with virtual variables. If a GIC product exists in a certain year, it is assigned a value of 1; otherwise, it is assigned 0. The other is expressed by the cumulative number of certifications in each year (Raimondia, 2016). Compared with the former, the latter considers the long-term effectiveness of the certification of GI products; thus, it can better measure the impact of GIC on the technical complexity of exporting products. Therefore, this study uses the cumulative certification quantity of each province in each year to measure GIC. As the certification of GIs contains information, such as quality reputation and technical standards, identifying product quality is important for consumers. It plays a significant role in promoting the export quality of agricultural products. The data are collected from the GI product retrieval platform of the State Intellectual Property Office.

2.2.3 Human Resource Endowment (humendow)

Intellectual capital accumulation is often the premise for obtaining high quality products (Jahanger et al., 2022), thus positively promoting the technical complexity of export. The index is expressed as the logarithm of the ratio of the number of students in each province to the resident population. The data are from statistical yearbooks of different provinces.

2.2.4 Agricultural Added Value (Agrvalue)

The agriculture added value represents the level of the added value of agricultural products, and the added value of products is often associated with a higher technical complexity of export (Rehman et al., 2021). It is expressed as the logarithm of the agricultural added value of each province. The data are from rural statistical yearbooks of each province.

2.2.5 Degree of Opening (Open)

It is expressed as the logarithm of the ratio of the total trade volume of each province to the GDP of each province. The data are from the statistical yearbooks of each province. In recent studies, the conclusions about the environmental performance of economic globalization are inconsistent (Yang et al., 2021; Kamal et al., 2021; Usman and Jahanger, 2021; Usman et al., 2022). Therefore, more evidence is needed to support it.

2.2.6 Agricultural FDI

Relevant research indicates that FDI has a significant technology spillover effect, which promotes export technology complexity (Usman and Jahanger, 2021). The logarithmic value of agricultural FDI in each province is used to measure it. The data source is the rural statistical yearbook of each province.

2.2.7 Agricultural Technology Innovation (AgrRD)

Technology is an important factor that affects the technical complexity of export. The index is expressed as the logarithm of the total R&D of each province, and the data source is the rural statistical yearbook of each province. **Table 1** presents the results of the statistical description of each variable.

3 FEATURE DESCRIPTION

GIs (GI) are a few of the core forms of property rights in TRIPS (Agreement on Trade-Related Aspects of Intellectual Property Rights). Since the agreement came into effect in 1994, GIC has largely promoted the establishment and development of GIC systems in various countries. According to the requirements of TRIPS, China issued the Agreement on the Protection of Products of Origin in 1999. However, it was not until 2005 that the improved and specialized document titled, Regulations on the Protection of GIs Products, was officially released. Moreover, three departments were set up in the early certification of GI products—State Administration for Industry and Commerce; General Administration of Quality Supervision, Inspection, and Quarantine; and the Ministry of Agriculture. Since 2018, under the unified management of the newly established State "Intellectual Property Office," both the number of certifications and the market perception have significantly improved. Therefore, this study analyzes the report issued by the State Intellectual Property Office in 2005

TABLE 1 | Descriptive statistics of the main variables.

Variable	Var-Des	Obs	Mean	Sd	Min	Max
LnGI	GI cumulative certification number	465	2.68	1.22	0	5.34
Lnhumendow	Human resource endowment	465	0.35	1.36	−4.61	4.02
LnAgrvalue	Added value of agriculture	465	6.77	1.17	3.24	8.60
Lnopen	Degree of opening	465	0.94	0.98	−1.70	3.20
LnAgrFDI	The value of agricultural FDI	465	6.08	1.59	1.39	9.88
LnInternet	Internet penetration	465	3.46	0.71	1.07	4.36
lnAgrRD	Agricultural R&D	465	0.12	0.69	−1.97	1.79

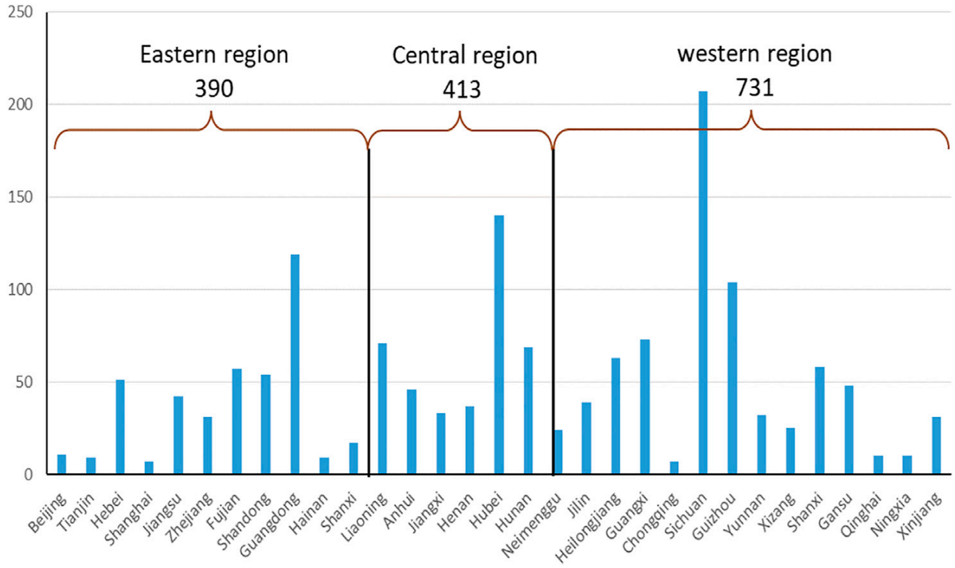

FIGURE 1 | Regional distribution of GIC in china (2005–2019) (unit: each). Data source: Patent Search Platform of State Intellectual Property Office.

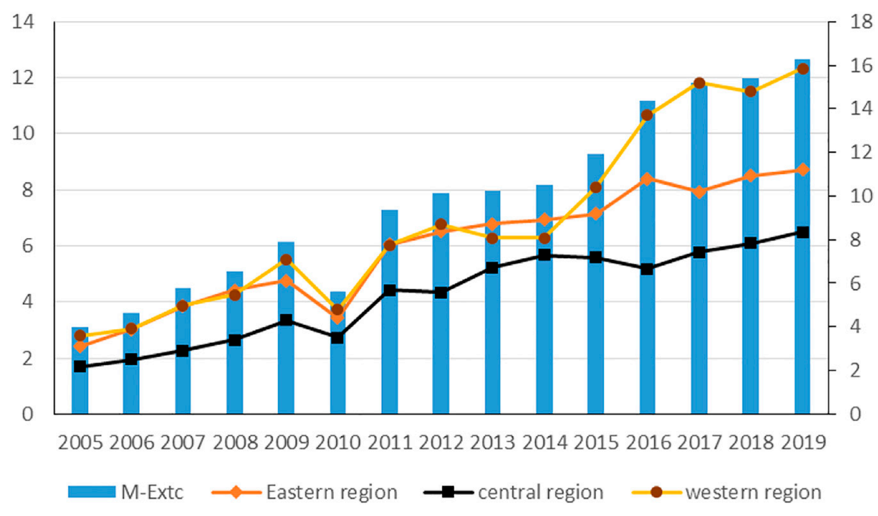

FIGURE 2 | Regional distribution of the technical complexity of export agricultural products (2005–2019) (unit: each). Data source: China's customs database. Note: 1) M-Extc represents the annual average export technical complexity index. 2) M-Extc is displayed on the right axis, and the technical complexity of different areas are displayed on the left half axis.

TABLE 2 | Benchmark regression of the impact of GIC on the technical complexity of export agricultural products.

Variable	(1)	(2)	(3)	(4)
LnGI	0.415*** (0.019)	0.134*** (0.04)	0.285*** (0.055)	0.140*** (0.046)
LnHumendow		0.032** (0.016)		0.041*** (0.015)
LnAgrvalue		0.383*** (0.086)		0.326*** (0.092)
Lnopen		−0.752*** (0.050)		−0.842*** (0.051)
LnAgrFDI		−0.049 (0.039)		-0.116** (0.049)
LnInternet		0.151** (0.067)		0.338*** (0.080)
lnAgrRD		0.229** (0.092)		0.300*** (0.091)
Constant	0.486*** (0.054)	−4.379*** (0.467)	0.674*** (0.073)	−4.418*** (0.598)
Year	No	No	Yes	Yes
Region	No	No	Yes	Yes
R-squared	0.520	0.741	0.578	0.795
Observation	465	450	465	450

T statistics in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

to better understand the influence of the certification of GI products on the technical complexity of export agricultural products.

Figure 1 depicts the quantitative characteristics of GIC in China's provinces and regions. Overall, the regional distribution of GIC products reveals an opposite trend with the level of economic development. It reflects the dependence of GIC on a specific environment and geographical location. However, the quality reputation of GI products forms a strong incentive for producers in areas where economic development is relatively lagging behind. Ultimately, it is conducive to improving the overall technical complexity of export agricultural products.

The results in **Figure 2** support this inference. Thus, the technical complexity of export agricultural products is characterized by the distribution of "high at both ends and low in the middle." The western region has a higher level of overall export technology complexity. The eastern region relies more on its technological and market advantages to cultivate GI products. The technical complexity of export agricultural products steadily improves by maintaining a relatively high number of GI products. However, due to the population and economic advantages of the eastern region, its GI products may be more digested by the domestic market, which has a crowding-out effect on the export scale and technical complexity of the export market. In comparison, the cumulative number of GI products in the central region has reached 413 types. However, the technical complexity of export is at a relatively low level, and the growth rate continues to slow down. It somewhat indicates that the quality guidance function of GI products in central China has not been fully exerted. The recognition in the international market still needs improvement.

4 BENCHMARK REGRESSION

Table 2 presents the basic regression results. Columns (1) and (2) report the results of uncontrolled provincial and annual effects. We find that GIC significantly improves the technical complexity of export agricultural products. After controlling the regional and annual effects, this conclusion is still supported; columns (3) and (4) report these results. "Trade openness" and "agricultural FDI" have negative effects on the technical complexity of export agricultural products. The possible explanation is that whether it is trade openness or FDI, the increase in export adds more value to China's agricultural exports. The quality improvement effect caused by technology and management spillovers has not been brought into full play in the agricultural field. Therefore, similar to the upgrading and adjustment of China's industry, the opening up and the improvement of FDI quality and efficiency also require full attention.

5 QUANTILE REGRESSION

To investigate the ladder effect of GIC on the technical complexity of exporting different agricultural products, this study further discusses this dynamic effect using quantile regression (Rehman et al., 2021; Usman and Jahanger, 2021; Fareed et al., 2022). **Table 3** presents the results. In terms of static effect, under different quantile conditions, GIC significantly promotes the technical complexity of export agricultural products. From the dynamic characteristics, GIs have a positive spillover effect on the added value of agricultural products for exports. Additionally, this effect is strengthened with the improvement of the technical complexity of products. However, the coefficient at 85% has declined, reflecting that the international recognition of GIC in China still needs improvement.

6 ROBUSTNESS TEST

To improve the reliability of the results, this study first replaces the GI variables with binary virtual variables and assigns a value of 1 if certified agricultural products exist in a certain year; otherwise, a value of 0 is assigned. Column 1 of **Table 4** presents the results. The result supports that GIC has a positive

TABLE 3 | Quantile regression of the impact of GIC on the technical complexity of export agricultural products.

Variable	25%	45%	65%	85%
LnGI	0.117** (0.058)	0.191*** (0.066)	0.133** (0.058)	0.121*** (0.040)
LnHumendow	0.042** (0.018)	0.039* (0.021)	0.040** (0.018)	0.021* (0.012)
LnAgrvalue	0.406*** (0.115)	0.266** (0.132)	0.351*** (0.12)	0.397*** (0.079)
Lnopen	−0.785*** (0.064)	−0.826*** (0.073)	−0.810*** (0.064)	−0.660*** (0.044)
LnAgrFDI	−0.132*** (0.062)	−0.154** (0.071)	−0.082 (0.062)	−0.090** (0.042)
LnInternet	0.309*** (0.099)	0.367*** (0.113)	0.278*** (0.099)	0.297*** (0.068)
LnAgrRD	0.309*** (0.113)	0.288** (0.129)	0.240** (0.113)	0.127 (0.077)
Constant	−2.742*** (0.648)	−1.922*** (0.740)	−2.356*** (0.647)	−1.994*** (0.442)
Year	Yes	Yes	Yes	Yes
Region	Yes	Yes	Yes	Yes
Observation	450	450	450	450

*T statistics in parentheses; * p < 0.1, ** p < 0.05, *** p < 0.01.*

TABLE 4 | Robustness test of the impact of GIC on the technical complexity of export agricultural products.

Variable	Dummy	mle	2sls
GI-dummy	0.065* (0.037)		
LnGI		0.140*** (0.044)	
LaglnGI			0.006* (0.003)
LnHumendow	0.041*** (0.015)	0.041*** (0.014)	0.119*** (0.036)
LnAgrvalue	0.367*** (0.092)	0.326*** (0.087)	0.072 (0.063)
Lnopen	−0.851*** (0.052)	−0.842*** (0.048)	−0.149** (0.066)
LnAgrFDI	−0.104** (0.050)	−0.116** (0.047)	0.063 (0.051)
LnInternet	0.366*** (0.079)	0.338*** (0.075)	0.464*** (0.096)
LnAgrRD	0.301*** (0.092)	0.300*** (0.086)	−0.353*** (0.099)
Constant	−4.774*** (0.585)	−4.379*** (0.467)	−1.563** (0.661)
Year	Yes	Yes	Yes
Region	Yes	Yes	Yes
R-squared	0.792		0.176
Observation	450	450	420
KP wald rk F			93.894***
KP rk LM			56.361***
CD wald F			282.251***
Hausman test			10.45***
DWH test			10.69***

*T statistics in parentheses; * p < 0.1, ** p < 0.05, *** p < 0.01.*

effect on the technical complexity of export agricultural products. The MLE (Maximum Likelihood Estimate) estimation results in column 2 of **Table 4** reveal that the results support the previous conclusions. The coefficients of the related variables are also consistent with the previous ones. As GIC contains information such as reputation and other technical standards, an endogenous problem may exist with the complexity of export technology. Therefore, we take the first-stage lag term of GIC as the tool variable and use 2SLS estimation and GMM estimation to test the endogeneity. Columns (3) and (4) of **Table 4** present the results. GIC still plays a steady role in promoting the technical complexity of export agricultural products. In addition, this study verifies the rationality of tool variable selection using the LM test and the Wald rk-F test of Kleibergen and Paap (2006) to ensure the validity of the tool variable.

TABLE 5 | Heterogeneity analysis based on different provinces.

Variable	Eastern region	Central region	Western region
LnGI	0.140** (0.063)	0.036 (0.094)	0.256*** (0.095)
lnHumendow	0.059** (0.026)	0.016 (0.033)	0.040 (0.025)
LnAgrvalue	0.206* (0.119)	0.744*** (0.186)	0.457 (0.287)
Lnopen	−0.537*** (0.132)	−0.539*** (0.124)	−0.849*** (0.090)
LnAgrFDI	−0.015 (0.066)	−0.137 (0.136)	−0.165 (0.111)
LnInternet	0.093 (0.139)	0.109 (0.118)	1.324*** (0.290)
LnAgrRD	0.252* (0.149)	0.191 (0.217)	0.624*** (0.212)
Constant	−1.791* (0.917)	−5.837*** (1.428)	−7.283*** (1.553)
Year	Yes	Yes	Yes
Region	Yes	Yes	Yes
R-squared	0.865	0.849	0.756
Observation	154	112	154

*T statistics in parentheses; * p < 0.1, ** p < 0.05, *** p < 0.01.*

7 HETEROGENEITY ANALYSIS

Due to the heterogeneity of economy, science and technology, human resources, and other factors in different provinces, this study investigates the inter-provincial heterogeneity of GIC on the technical complexity of export agricultural products (**Table 5**). Overall, the results in the eastern and western regions indicate the same promotion effect as the overall results, but the results in the central region are insignificant. The possible reason is that the eastern region pays extra attention to the certification of GI products because of its higher economic level and closer proximity to the market, and the product certification has obvious agglomeration characteristics. Moreover, the more open market conditions relatively reduce the degree of asymmetric information. This phenomenon has a certain degree of substitution effect on the quality guidance of GIC. Therefore, limited by the relatively lagging level of economic development and the relatively scattered distribution of resource endowments, the GIC products in the western region play a stronger role in promoting the quality and price bonus of export agricultural products and bringing stronger positive incentives to producers. The number of certified products in the central region is higher than that in the western region, but no significant evidence proves that the complexity of export technology is positively promoted. This reflects the excessive dependence of the region on natural resources endowment. Consequently, the awareness of GIC is weak and extensive. Therefore, we should pay attention to strengthening the publicity of GIC, enhancing the quality-oriented role of GI products, and promoting the added value level of export agricultural products.

8 CONCLUSION

Based on provincial micro panel data, this study discusses the impact of GI product certification on the technical complexity of export agricultural products. The results reveal that GIC products can significantly promote the technical complexity of export agricultural products. Moreover, this promotion effect will be strengthened with the improvement of the technical complexity of products. However, the coefficient at 85% quantile has declined, reflecting that the international recognition of China's GIC still needs improvement. Further heterogeneity analysis finds that the GIC products in the Eastern and Western regions significantly promote the technical complexity of export agricultural products. However, we do not find significant evidence regarding the results in central China to support this conclusion. This finding is consistent with the structural features in the feature description, which indicates that the GIC level is relatively weak in the central region. Although a large number of certified products exist in this region, they do not play an effective role in guiding the quality. Improving the added value of the corresponding export agricultural products is difficult for GIC.

The possible policy implications of this study are as follows. First, The government should continuously improve the certification system of GI products, actively participate in the international governance of intellectual property protection and the construction of international rules related to the GIC, and accelerate the internationalization process of GI products. Second, strengthen the supervision of GI products, strengthen the quality guidance ability of GI products, and enhance the incentive effect of GIC on producers. Finally, give full play to the government's policy guidance and support role. Establish a trinity industrial chain of government, enterprises, and farmers and form a standardized and professional circulation and industrial upgrading path of GI products to avoid excessive dependence on primitive natural resources.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding authors.

AUTHOR CONTRIBUTIONS

Conceptualization, ZX; methodology, ZX; software, YF; validation, ZX; formal analysis, ZX; investigation, YF; resources, YF; data curation, YF; writing—original draft preparation, ZX; writing—review and editing, ZX; visualization, HW; supervision, HW; project administration, HW; funding acquisition, ZX.

FUNDING

The project of philosophy and social science planning in Zhejiang Provincial Philosophy and Social Sciences Planning Project, 21NDQN235YB. Soft Science Project of Science and Technology Department of Zhejiang Province, 2021C35049.

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.