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Does global value chain engagement improve export quality? Evidence from Chinese manufacturing firms

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ABSTRACT

Using a firm-level data set of Chinese manufacturing sector, we examine whether global value chain (G.V.C.) engagement induces firms to upgrade the quality of the goods that they export. Empirical results show that G.V.C. participation has positive impact on export product quality, and this finding is consistent across several robustness checks. However, the influence of G.V.C. embedment on export quality presents an 'inverted-U' shape. The mechanism analysis demonstrates that the effect of G.V.C. participation on export quality is driven by competition effect and firms' willingness to import high-quality intermediates. Furthermore, the quality effect of G.V.C. embedment differs depending on firm characteristics. This article therefore contributes to a better understanding of the benefits of participation in G.V.C.s for manufacturing firms from developing countries.

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1. Introduction

Global value chains (G.V.C.s) are defined as 'fragmented supply chains, with internationally dispersed tasks and activities coordinated by a lead firm' (UNCTAD, 2013, p. 125). Due to the fast development and dissemination of information and communication technologies (I.C.T.) as well as the widespread adoption of trade liberalisation policies aimed at reducing trade barriers and cutting trade costs, the production value chains of multinational enterprises have become increasingly fragmented across countries. As a result, the rise of G.V.C.s became one of the most dominating trends in international trade and business during the last few decades, which has generated considerable public interest as well as extensive academic research.

Since the 1990s, numerous studies in different academic fields have explored a wide range of topics related to G.V.C.s, including G.V.C. governance, G.V.C. mapping, and G.V.C. consequences. International trade economists pay much attention to

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the decomposition or measurement of G.V.C.s (Koopman et al., 2008, 2010, 2014), the determinants of G.V.C. participation (Korwatanasakul & Baek, 2021; Lu et al., 2018), and the impact of G.V.C. participation on economic development and firm performance (Lu et al., 2019; Wang et al., 2021).

In particular, the literature has placed a lot of emphasis on China, which has been labelled the 'world factory'. Most of domestic and foreign enterprises in China import raw materials and intermediates for processing before exporting to foreign markets. This means that these firms are most likely coping with minimal domestic value added in their exports. A notable example is the manufacture of the iPhone. According to Kraemer et al. (2011), only 1.8% of the iPhone's pricing is used to pay the wages of Chinese assembly workers. In recent years, many papers have explored how Chinese firms have advanced up the G.V.C.s and how participation in the G.V.C.s affects firm performance to precisely map its G.V.C. position and dynamic mobility along the G.V.C.s. For instance, Upward et al. (2013) discovered that the domestic content of China's exports increased from 53% to roughly 60% between 2003 and 2006, using a variation of the method described by Hummels et al. (2001) that accounts for the presence of processing enterprises. Similarly, Kee and Tang (2016) used the Annual Survey of Chinese Industrial Firms (A.S.I.F.) and the China Customs Database (C.C.D.) to calculate the ratio of domestic value added in China's gross exports. They demonstrated that, despite its extensive involvement in G.V.C.s, China is a fascinating exception to the global downturn. Domestic content in Chinese exports climbed from 65% in 2000 to 70% in 2007.

Another related literature primarily concentrates on the impact of G.V.C. involvement on firm performance, which is more closely related to our study. For instance, Lu et al. (2019) explored whether and how China's engagement in the G.V.C. enhances firm wage, and the empirical findings reveal that G.V.C. engagement can improve wage level. Wang et al. (2021) investigated the role of G.V.C. embedment on wage inequality within firms and found that participation in G.V.C.s has an ambiguous impact on wage inequality within firms. Hua et al. (2022) found that firm's engagement in G.V.C. leads to decreased SO_2 emission.

Although the research on the impact of G.V.C. engagement on firm performance is increasing, their effects on export quality are yet examined. The improvement of product quality is crucial for promoting exports and sustainable growth because it is an important form of innovation in addition to improving production technologies and developing new products (Hayakawa et al., 2020). Hummels and Klenow (2005) have shown that about 9% of the difference in real income per worker across countries can be attributed to differences in export quality. Given the importance of the export quality, several papers have examined the determinants of export quality upgrading. These papers find a wide variety of factors affecting firm-level export quality. For example, Anwar and Sun (2018) found that an increase in foreign presence in China's manufacturing sector contributes to a significant increase in China's export quality. Hayakawa et al. (2020) showed that the liberalisation of services foreign direct investment has a positive impact on exporting firms' quality upgrading in China. Fan et al. (2015) presents theory and evidence that tariff reduction induces a country's producers to upgrade the quality of their exports. Hu et al. (2021) show that an import currency

appreciation that makes imported intermediates cheaper allows firms to switch to higher quality intermediates, thus permitting higher quality exports.

Nevertheless, we have not found any work that directly examines how firms' participation in G.V.C.s affects the quality of exporting products. A better knowledge of the influence of G.V.C.s on export quality is critical to understanding the benefits of G.V.C. embedment, which can provide us with significant development policy insights. To the best of our knowledge, there has been little theoretical and empirical research on the export quality impacts of China's rising participation in the G.V.C., particularly at the firm level. As a result, we contribute to the existing literature in the following ways. First, we study if and how a firm's G.V.C. engagement affects the quality of its export products. In comparison to prior research that studied whether a firm enters the export market and how this impacts the quality of export products, our study is more comprehensive because it incorporates these factors from the perspective of G.V.C.s. In addition, we investigate if there is a nonlinear relationship between G.V.C. embedment and export product quality. Second, we investigate the potential mechanisms through which G.V.C. embedment affects export quality. The competition and high-quality imported input channels have been found and proven empirically. Finally, we analyse the heterogeneous effects of a firm's G.V.C. engagement by separating different types of ownership and trade. Our findings not only help us identify new benefits of participation in G.V.C.s, but they also have important implications for politicians and business managers.

2. Research hypothesis, econometric specification and data

2.1. Research hypothesis

Product quality improvement is a key driver of economic growth. Antoniades (2015) showed that lower production costs are linked to higher product quality in a theoretical model of heterogeneous firms with endogenous quality upgrading. According to his model, the potential for quality differentiation increases along with firm productivity, indicating that raising quality can boost a company's profitability. As a result, the cost of adopting quality in the production process is declining while the market size and consumers' taste parameters for quality are growing. The model by Verhoogen (2008) shows that increased access to destination markets stimulates exporting firms to employ more skilled workers and thereby upgrades the quality of their respective products, while Bustos (2011) theoretically and empirically showed that trade liberalisation promotes the adoption of high technology which leads to higher-quality goods. Kugler and Verhoogen (2012), who considered an endogenous choice of both input and output quality, theoretically showed that plants with higher productivity use high-quality inputs and produce high-quality products.

Although there is no theoretical model directly related the G.V.C. to export quality, we can still draw hypotheses that firms' engagement in G.V.C. can help improve their export quality based on the quality upgrading models we discussed above. Specifically, we focus on two influential paths. One path is based on competition effect when the firms participate in G.V.C.s. A reduction in output and input tariffs intensifies product competition in the domestic and foreign markets and changes

domestic and exporting firms' incentives to innovate and upgrade product quality (Amiti & Khandelwal, 2013). On one hand, increased competition could reduce firms' pre-grade profits, inducing them to improve product quality. On the other hand, increased market size increases ex-post profits, decreasing the cost of quality adoption in the production process. Chiarvesio et al. (2010) show that when the firms become part of global networks many leading firms decide to renovate their business strategy by upgrading their products and investing in new brands and sales channels to face international competition and win the market dynamics.

The other path that firms' G.V.C. participation affects export quality is due to the imported inputs. More variety and high quality of inputs might be indispensable to produce high-quality products. When the firms embed themselves into the G.V.C.s, they can have better access to high-quality intermediate products and services of foreign providers, which facilitates the exchange of ideas, know-how, and technology in upgrading product quality (Hayakawa et al., 2020). Moreover, better input quality enables firms to make higher mark-ups in foreign markets, which may create room for firms' investment in product quality. Manova and Zhang (2012) show that Chinese firms that are relatively more successful in export market tend to use higher quality inputs, which allows them to export higher quality products.

However, it is worth noting that manufacturing enterprises in developing countries typically rely on labour and natural resources as their primary competitive advantages while participating in G.V.C.s. As a result, they are limited to resource-intensive processing and manufacturing tasks of low value. The quality of products and their global competitiveness continue to improve as enterprises get more deeply embedded in the G.V.C.s. When the quality of the products reaches a certain level, the interests of transnational multinational corporations may be compromised. As a result, once these enterprises reach a certain degree of G.V.C. embedment, foreign multinational corporations will limit their exports of high-tech intermediate inputs to developing-country firms. As a result, the export quality of the firms in developing countries would be suppressed. We therefore present three hypotheses:

Hypothesis 1: G.V.C. participation can assist enterprises in improving the quality of their exports.

Hypothesis 2: The relationship between G.V.C. embedment and export product quality is more likely to be non-linear, with the effect taking on a 'inverted U' shape and the marginal improvement shifting from growing to decreasing.

Hypothesis 3: G.V.C. embedment primarily improves the quality of corporate export products through the competitive effect and the importation of higher-quality intermediate inputs.

2.2. Econometric specification

We ran the following regression to empirically examine the effects of G.V.C. embedment on export quality:

$$TQ_{it} = \alpha_i + \beta GVC_{it} + \gamma X_{it} + HHI_{ijt} + \upsilon_t + \varepsilon_{it} \quad (1)$$

where the subscriptions i, j, and t, represent firm, industry and year, respectively. The dependent variable, TQ_{it}, is the quality of export products of firm i in year t, and GVC_{it} represents the degree of G.V.C. embedment of firm i in year t. X_{it} is a vector of firm-level control variables. α_i is the firm fixed effects, controlling for all time-invariant characteristics across firms, υ_t is the year fixed effects, controlling for all yearly shocks common to firms, such as business cycles, and ε_{it} is the error term.

To isolate the effect of G.V.C. embedment, we control for several time-varying firm and industry characteristics that may affect export quality of firms, such as total factor productivity (TFP_{it}), firm size ($size_{it}$), firm age (age_{it}), financial constraints ($finance_{it}$), research and development ($rdeff_{it}$), and the Herfindahl index (HHI_{ijt}), which measures the industrial competition of industry j where firm i operates. The measurement of these control variables is introduced in 2.3.3.

2.3. Measurements of the variables

2.3.1. Degree of G.V.C. embedment

Upward et al. (2013) calculated the foreign value-added rate (F.V.A.R.) to stand for G.V.C. embedment using the A.S.I.F. and C.C.D. This method assumes that all commodities imported by processing firms are used to produce export products for processing trade, whereas commodities imported by ordinary trade are used to produce domestic sales and ordinary trade exports based on the relative proportions of domestic sales and ordinary trade exports. Then, we can derive the F.V.A.R. equation as follows:

$$FVAR_{it1} = \frac{V_{it}^{F}}{X_{it}} = \frac{M_{it}^{p} + X_{it}^{o}\left[M_{it}^{o}/(D_{it} + X_{it}^{o})\right]}{X_{it}} \tag{2}$$

where $FVAR_{it1}$ represents the F.V.A.R. of total exports of firm i in year t, V_{it}^{F} represents the foreign value-added part of total exports of firm i in year t, X_{it} and X_{it}^{o} represent the total exports and ordinary trade exports of firm i in year t respectively, D_{it} represents the domestic sales of firm i in year t, M_{it}^{o} and M_{it}^{p} represent the ordinary trade imports and processing trade imports of firm i in year t, respectively. In particular, the firm's import and export data are obtained from the C.C.D., and domestic sales data are calculated by subtracting total exports from total sales. If the firm's total exports of that year exceed sales, it is assumed that the firm's foreign value-added of exports (V_{it}^{F}) equals the sum of ordinary trade imports (M_{it}^{o}) and processing trade imports (M_{it}^{p}). If the firm's foreign value-added of exports exceeds total exports, we set the F.V.A.R. of the firm's exports to 1.

To address the shortcomings of the approach stated in Equation (2), we reconstruct the equation following Lv et al. (2017). First, we categorise imported products using the United Nations' concordance table of Broad Economic Categories (B.E.C.) and Harmonised System (H.S.) customs codes, and we exclude capital and consumer commodities from ordinary imports. Second, we identify intermediary traders. Samples of intermediate firms whose names in the C.C.D. contain 'import and export', 'trade', 'foreign economics', 'economics and trade' or 'science and trade' are deleted in order to correctly evaluate the degree of G.V.C. embedment. The foreign value-added (V_{it}^{F}) in the Equation (2) is revised to the actual foreign value-added of

the firm (V_{it}^{AF}). The processing trade imports (M_{it}^{p}) is revised to the actual imports of processing trade (M_{it}^{Ap}), and the ordinary trade imports (M_{it}^{o}) is revised to actual intermediate input imports of ordinary trade (M_{it}^{Ao}). Third, there are indirect imports. We need to identify over-importing firms that import an excessive amount of intermediate inputs from processing trade enterprises and sell the excess intermediate inputs to other domestic firms, as well as over-exporting firms that acquire intermediate inputs from domestic firms and utilise them to generate export products. There will be significant differences in the international value-added of exports between the two types of enterprises. The former may have an F.V.A.R. more than one, while the latter may have an F.V.A.R. near to zero. Finally, it is necessary to consider the foreign components of domestic intermediate input. Firms employ some foreign content in their domestic intermediate products. According to Koopman et al. (2012), this is between 5% and 10%. This component is also part of the V_{it}^{AF} and should be calculated.

In this article, we assume that China's domestic intermediate inputs comprise 5% foreign content.[1] The measurement employed by Lv et al. (2017) for the F.V.A.R. of Chinese enterprises' exports is obtained using the four steps described above, as shown in Equation (3):

$$FVAR_{it2} = \frac{V_{it}^{AF}}{X_{it}} = \frac{\left\{M_{it}^{Ap} + X_{it}^{o}\left[M_{it}^{Ao}/(D_{it} + X_{it}^{o})\right]\right\} + 0.05\left\{M_{it}^{T} - M_{it}^{Ap} - M_{it}^{Ao}\right\}}{X_{it}} \tag{3}$$

where M_{it}^{T} represents the intermediate inputs of firm i in year t. In contrast, following Lv et al. (2017), we further improved the F.V.A.R. measure, that is, when stripping off the foreign content contained in domestic intermediate products, only the export part of the firm's sales is stripped, as shown in Equation (4):

$$FVAR_{it3} = \frac{V_{it}^{AF}}{X_{it}} = \frac{\left\{M_{it}^{Ap} + X_{it}^{o}\left[M_{it}^{Ao}/(D_{it} + X_{it}^{o})\right]\right\} + 0.05\left\{M_{it}^{T} - M_{it}^{Ap} - M_{it}^{Ao}\right\} \times \left[X_{it}/(X_{it} + D_{it})\right]}{X_{it}} \tag{4}$$

2.3.2. The quality of export products

Following Khandelwal et al. (2013) and Shi (2013), this study defines 'quality' as any attribute which raises consumer's demand other than price. Given the utility function,[2] quality can be inferred from the observed price and demand. Following Khandelwal et al. (2013), we denote the quantity of a certain product that firm i exported to country m in year t as λ_{imt}, and it satisfies the following demand function:

$$q_{imt} = p_{imt}^{-\sigma}\lambda_{imt}^{\sigma-1}\frac{E_{mt}}{P_{mt}} \tag{5}$$

where q_{imt} denotes the demand for the product that has been exported by firm i to destination m in year t. p_{imt} represents the price of the product that firm i exported

to country m in year t. E_{mt} and P_{mt} capture the consumer spending and price index of country m in year t. σ represents the elasticity of substitution between products. Taking logs of both side of Equation (5), we obtain the following equation:

$$\ln q_{imt} = \chi_{mt} - \sigma \ln p_{imt} + \varepsilon_{imt} \tag{6}$$

where $\chi_{mt} = \ln E_{mt} - \ln P_{mt}$ is the importing country-year two-dimensional dummy variable, which controls income and price index of country m in year t. $\ln p_{imt}$ represents the unit value of the firm's export products, $\varepsilon_{imt} = (\sigma - 1)\ln\lambda_{imt}$ is the residual item containing information of export product quality. It should be noticed that Equation (6) targets a specific product under the octal customs code, implying that the estimation of Equation (6) is done at the product level. Therefore, it naturally controls product features. Since the p_{imt} is endogenous, we therefore use instrumental variable estimation to address the potential issue of the endogeneity of the price. We employ the average price of firm i exporting to the other markets other than market m to instrument the export price in market m. Then the export product quality can be defined as:

$$\text{quality}_{imt} = \ln\hat{\lambda}_{imt} = \frac{\hat{\varepsilon}_{imt}}{(\sigma - 1)} = \frac{\ln q_{imt} - \ln\hat{q}_{imt}}{(\sigma - 1)} \tag{7}$$

Since the data obtained by directly adding the quality information of different products has no obvious economic significance, and if we want to obtain the quality information at the firm level, we must also add the quality information at the product level, therefore, we standardise the quality data of (7) to obtain the standardised quality indicators of each product of each firm at each 'year-market' level, as shown in Equation (8):

$$\text{Squality}_{imt} = \frac{\text{quality}_{imt} - \text{minquality}_{imt}}{\text{maxquality}_{imt} - \text{minquality}_{imt}} \tag{8}$$

Among them, maxquality_{imt} and minquality_{imt} are the maximum and minimum of the export quality of a H.S.6-digit level product found in all years, all firms, and all importing countries level, respectively. Equation (8) shows that the standardised quality index is between 0 and 1, and there is no unit. It can be aggregated to obtain the export product quality index at the firm level using the following formula:

$$TQ_{it} = \frac{v_{imt}}{\sum_{im\epsilon\Omega} v_{imt}} \times \left(\text{Squality}_{imt}\right) \tag{9}$$

Among them, TQ_{it} represents the export product quality of the firm i in year t, Ω represents the products set that firm i export in year t, and v_{imt} represents the value of the products.

2.3.3. Control variables

In addition to the key explanatory variables, we also control the following variables. The export quality of larger firm might be higher, and hence, the first variable we control is firm size (size). We use logarithm of the total employee to capture firm size. The second variable we control is firm age (age). The firm age is introduced to capture the effect of production experience on the quality of firms' export products, the longer the enterprises survive, the richer the production experience, and therefore, the higher the export quality will be. We use log (the current year − the opening year + 1) to estimate firms' age. A firm's T.F.P. is a key factor affecting export quality, and we estimate the firm-level T.F.P. using the method developed by Petrin et al. (2004). The inclusion of financial constraints (finance) is to test whether a firm facing financial constraints tends to sacrifice the export quality, in which we use the ratio of net account receivables to total assets to measure financial constraints. In addition, firms' innovation activities can result in a brand effect, and for many consumers, brand is synonymous with product quality. We therefore include the fifth variable research and development (rdeff) in the regressions. According to Xu and Lu (2009), in accounting, patents and trademarks are generally called intangible assets, patents and trademarks are closely related to research and development, and hence, we use the ratio of intangible assets to total assets to measure research and development.

Moreover, fierce industry competition might force businesses to improve their product quality, and we use the H.H.I. to capture the impact of industry competition. Specifically, it is represented by the sum of the squares of the market shares of all firms in the industry, $HHI = \sum_{i=1}^{N} (S_i/S)^2$, where N represents the number of firms in the industry, and S_i represents the market size of firm i, and S represents the overall market size of a specific industry (this article denotes exports as the market size).

In the mechanism analysis, we also need firm-level G.V.C. position (position) and the quality of imported intermediate products (T.Q. import). In the calculation of position, this article firstly refers to the method of Antràs and Chor (2018) to measure the upstreamness and downstreamness of the 'national-industry' level, and then takes the method of Chor et al. (2021) to match the upstreamness and downstreamness to the C.C.D. to obtain the firm-level upstreamness and downstreamness, and finally the position is measured as the ratio of the upstreamness to the downstreamness following Wang et al. (2017). In addition, we use the approach estimating the quality of export products to calculate the quality of import products.

2.4. Data

Our empirical analysis is based on two data sets: (1) C.C.D. during 2000–2010; (2) Annual Survey of Chinese Industrial Firms (A.S.I.F.) over the same period. The C.C.D. provides all Chinese firms' trade information, which records the origin country of imports as well as the destination of exports and contains firm specific information such as name, address, ownership, and trade regime, etc. The A.S.I.P. data set provides firm-level production information for comprehensive state-owned enterprises (S.O.E.s) and non-S.O.E.s with annual sales exceeding 5 million RMB. We merge the two data sets in two steps following Upward et al. (2013). First, we use

firm name with years to match the customs transaction- and firm-level data. Second, the firms not matched in the first step are further matched according to the last seven digits of the firm's telephone number and the postal code of the firm's location by years. The initial customs data recorded at the H.S. 8-digit level are aggregated to the H.S. 6-digit level to avoid potential coding errors. We exclude the data without critical information for the following analysis. We also drop trading companies that only act as trade intermediaries.

3. Estimation results

3.1. Baseline results

We use Equation (1) to perform a baseline regression on the data, and the benchmark results are shown in Table 1. Among them, the standard error is clustered at the firm level. In addition, the year fixed effect and the firm fixed effect have been included to all regressions in this article. To regress the quality of firms' export products (TQ) in Column (1), we only use the key explanatory variable the degree of G.V.C. embedment of firm (G.V.C.). The results show that the coefficient of G.V.C. is significantly positive at the 1% significance level, implying that G.V.C. embedment has a significant positive impact on the quality of firms' export products, i.e., as the degree of G.V.C. embedment increases, the quality of firms' export products improves. In addition, we further control the impact of firm size and firm age in columns (2) and (3). The results show that, despite a slight decrease in the coefficient of G.V.C., it is still significantly positive at the 1% significance level. The impact of firm size and firm age are shown positive, which means that large and old firms are more like to produce high-quality exporting products. The estimated coefficients in column (4) show the regression results after taking the firm's T.F.P. into account. The findings show that the G.V.C. coefficient is still significantly positive, although its size

Table 1. Baseline results.

	(1)	(2)	(3)	(4)	(5)	(6)
GVC	0.0248***	0.0224***	0.0225***	0.0200***	0.0216***	0.0217***
	(0.0033)	(0.0032)	(0.0032)	(0.0033)	(0.0034)	(0.0034)
size		0.0223***	0.0219***	0.0188***	0.0190***	0.0190***
		(0.0010)	(0.0010)	(0.0010)	(0.0010)	(0.0010)
age			0.0063***	0.0057***	0.0057***	0.0057***
			(0.0013)	(0.0013)	(0.0013)	(0.0013)
TFP				0.0088***	0.0087***	0.0087***
				(0.0005)	(0.0005)	(0.0005)
finance					0.0165***	0.0165***
					(0.0029)	(0.0029)
rdeff					0.0049	0.0048
					(0.0083)	(0.0083)
HHI						−0.0089**
						(0.0037)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
N	86,572	86,572	86,572	84,381	82,355	82,355
R^2	0.7838	0.7867	0.7868	0.7923	0.7918	0.7919

The values in parentheses are the standard errors clustered to the firm level.
*, ** and *** indicate significant at the significance level of 10%, 5% and 1%, respectively.
Source: Authors' own calculations.

slightly decreases again. The estimated coefficient of T.F.P. is significantly positive, implying that more productive firms can produce higher quality products.

Then, in column (5), we add financial constraints (finance) reflecting corporate financing conditions and research and development (rdeff) reflecting corporate research and development investment in column (5). The results show that after adding finance and rdeff, the coefficient of G.V.C. is still significantly positive, the magnitude of the coefficient rebounded slightly again, and passed the 1% significance test. Finally, we add the H.H.I., which represents the degree of industry competition, in column (6). The results show that the G.V.C. coefficient is still significantly positive at the 1% significance level, and the magnitude of the coefficient has basically not changed. The estimated coefficient of H.H.I. shows that more competitive industry is good for quality upgrading. In summary, we find that G.V.C. embedment has a significant positive impact on the quality of export products of firms. This result is still robust after adding some control variables at the firm and industry level.

3.2. Endogeneity

One question may be raised whether the positive relationship between G.V.C. embedment and export quality of firms is really a causal relationship. We may have reasons to suspect there are some omitted variables affecting firms' G.V.C. participation and export quality simultaneously or the export quality may affect the G.V.C. engagement. We therefore attempt to address the endogeneity issue by employing an instrument variable approach. Following Lv et al. (2018), we use lagged G.V.C. and average G.V.C. engagement of each 4-digit industry as instrument variables to run the two-stage least squares (2S.L.S.) regressions respectively. Table 2 presents the first stage and second stage regression results. The first stage results show the statistically positive estimates of both instruments on the G.V.C. engagement. Second stage results show the robustness of our results about the positive impact of G.V.C. embedment on export quality. The results in Table 2 are thus consistent with those from Table 1.

3.3. Non-linear relationship

According to Hypothesis 2, the relationship between G.V.C. embedment and the quality of firms' export products could be non-linear and has an 'inverted U' shape. To test if Hypothesis 2 holds, we add the square term of the degree of G.V.C. embedment in Equation (1) and rerun the regressions. The results are presented in column (1) of Table 3. We find that there is an 'inverted U' relationship between G.V.C. embedment and export product quality. This indicates that when the degree of G.V.C. embedment is low, increasing the degree of G.V.C. embedment can help promote the improvement of the quality of the firm's export products. However, when the degree of G.V.C. embedment is increased to a relatively high level, continuing embedding in the G.V.C.s will reduce the marginal return obtained by the quality of the firm's export products, and even reduce the quality of the firm's export products.

According to the regression results in column (1) of Table 3, the 'inverted-U' relationship between the G.V.C. embedment and the quality of the firm's export products

Table 2. Instrumental results of G.V.C. embedment on export quality.

	Lagged GVC		Industrial average GVC	
	First stage (1)	Second stage (2)	First stage (3)	Second stage (4)
lag GVC	0.0927***			
	(0.0116)			
Mean GVC			0.4901***	
			(0.0152)	
GVC		0.2266***		0.0634***
		(0.0601)		(0.0163)
size	0.0077***	0.0161***	0.0090***	0.0186***
	(0.0018)	(0.0015)	(0.0014)	(0.0010)
age	0.0018	0.0038*	−0.0030*	0.0059***
	(0.0023)	(0.0020)	(0.0016)	(0.0013)
TFP	−0.0037***	0.0086***	−0.0049***	0.0089***
	(0.0010)	(0.0008)	(0.0008)	(0.0006)
finance	−0.0179***	0.0189***	−0.0255***	0.0175***
	(0.0053)	(0.0042)	(0.0041)	(0.0029)
rdeff	−0.0016	0.0162	−0.0193*	0.0059
	(0.0127)	(0.0112)	(0.0102)	(0.0084)
HHI	0.0255***	−0.0095*	0.0126**	−0.0097***
	(0.0081)	(0.0054)	(0.0060)	(0.0038)
Year FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Observations	41,411	41,411	82,355	82,355
R-squared	0.0108	−0.0763	0.0459	0.0172
Wald test		63.978 [0.000]		1037.107 [0.000]

The values in parentheses are the standard errors clustered to the firm level.
*, ** and *** indicate significant at the significance level of 10%, 5% and 1%, respectively.
Source: Authors' own calculations.

has a critical value of 0.5949. However, the average value of the degree of G.V.C. embedment is 0.1753 in our sample, which is considerably below the crucial threshold of 0.5949. This indicates that Chinese enterprises' participation in G.V.C. is still in the process of increasing the quality of their export products. We discover that most of the firms in the sample are on the left side of the crucial value of the 'inverted U' curve relationship. Approximately 5.91% of enterprises with a high degree of G.V.C. embedment are reducing the quality of their export products. This means that, except for 5.91% of firms with an extremely high degree of G.V.C. embedment, the impact of G.V.C. embedment on the quality of Chinese firms' export products is still in the promoting stage, and Chinese firms can improve the quality of their export products by increasing the degree of G.V.C. embedment.

3.4. Mechanism analysis

According to Hypothesis 3, when firms encounter the competitive consequences of G.V.C. embedment (Chiarvesio et al., 2010), market rivalry will increase the quality of the firm's export products. According to the 2014 W.T.O. report, enterprises' competitive pressure is positively associated to their G.V.C. position. When enterprises in lower G.V.C. positions enter the G.V.C. upgrade stage, they will encounter increased competitive pressure. To that end, this article conducts a mechanism verification using the firm's G.V.C. position. Firms will use more high-quality imported intermediate products in production (especially in the production of export products) in

Table 3. 'Inverted U' effect and mechanism analysis.

	'Inverted U' verification (1)	Competitive mechanism (2)	Import product quality mechanism (3)	Two mechanisms (4)
GVC	0.0589***	−0.0479**	−0.0977***	−0.1625***
	(0.0091)	(0.0186)	(0.0145)	(0.0254)
GVC^2	−0.0495***			
	(0.0113)			
position		−0.0049		−0.0074
		(0.0065)		(0.0089)
GVC × position		0.0623***		0.0687***
		(0.0188)		(0.0229)
TQ import			0.0495***	0.0502***
			(0.0062)	(0.0062)
GVC × TQ import			0.1490***	0.1439***
			(0.0217)	(0.0218)
size	0.0189***	0.0201***	0.0178***	0.0180***
	(0.0010)	(0.0013)	(0.0014)	(0.0014)
age	0.0057***	0.0080***	0.0074***	0.0076***
	(0.0013)	(0.0019)	(0.0022)	(0.0022)
TFP	0.0087***	0.0078***	0.0066***	0.0065***
	(0.0005)	(0.0007)	(0.0007)	(0.0007)
finance	0.0164***	0.0215***	0.0195***	0.0186***
	(0.0029)	(0.0037)	(0.0040)	(0.0040)
rdeff	0.0047	−0.0216*	−0.0304**	−0.0308**
	(0.0083)	(0.0120)	(0.0145)	(0.0145)
HHI	−0.0090**	−0.0078*	−0.0054	−0.0050
	(0.0037)	(0.0043)	(0.0049)	(0.0049)
Year FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
N	82,355	54,640	44,893	44,527
R^2	0.7920	0.8012	0.8051	0.8059

The values in parentheses are the standard errors clustered to the firm level. *, ** and *** indicate significant at the significance level of 10%, 5% and 1%, respectively.
Source: Authors' own calculations.

order to better enter foreign markets, and the use of high-quality intermediate inputs will improve the quality of the firm's final products (Kugler & Verhoogen, 2012). As a result, we believe that the export quality effect of G.V.C. embedment stems primarily from the competitive effect and the improvement of the quality of imported intermediate inputs. To test the mechanism of this article, we set the regression as follows to verify Hypothesis 3,

$$TQ_{it} = c_0 + c_1 GVC_{it} + c_2 channel_j + c_3 GVC_{it} \times channel_j + c_4 X_{it} + \upsilon_t + \varepsilon_{it} \quad (10)$$

Among them, k=1, 2, $channel_1$ and $channel_2$ respectively represent the two possible channels of the competitive mechanism and the import product quality mechanism. First, the data in column (2) of Table 3 reports the estimation results of the competitive mechanism. The results show that the coefficient of the interaction term G.V.C. × position is positive and passed the 1% significance test, which indicates that firms in a higher position of G.V.C.s can achieve the effect of export product quality upgrading due to strong competitive pressure. The data in column (3) of Table 3 reports the test results of the quality mechanism of imported products. The results show that the coefficient of the interaction term G.V.C. × TQ import is significantly positive at the significance level of 1%, which indicates that in the process of

participating in the G.V.C.s, firms that import high-quality intermediate products have more prominent export product quality improvement effect of G.V.C. embedment. Finally, we simultaneously test the two mechanisms in column (4) of Table 3, and the estimation results once again verify our hypothesis, G.V.C. embedment can improve the quality of corporate export products by channels of competitive effects and importing more higher quality intermediate inputs.

3.5. Heterogeneity analysis

We believe that the heterogeneous characteristics of enterprises will have an impact on the G.V.C. embedment's export product quality effects. As a result, we choose ownership, trade patterns, and the diversity of export products as test objects and assess the heterogeneous impact of the quality effects of G.V.C.-embedded export products.

3.5.1. Firm ownership

According to the previous studies, we notice that firms with different ownerships have different market behaviour and firm performance. For example, foreign enterprises are always found to be more productive and innovative. S.O.E.s seem less foreign-oriented. To investigate whether the quality effects of G.V.C. embedment export products differ due to firm ownership, we divide the sample into several sub-samples based on firm ownership, with three sub-samples of state-owned firms, private firms, and foreign-funded firms with a relatively large number of samples left for verification. Table 4 displays the results. Columns (1) to (2) show the test

Table 4. Estimation results based on the type of firm ownership.

	State-owned firms		Private firms		Foreign-funded firms	
	(1)	(2)	(3)	(4)	(5)	(6)
GVC	0.0270	0.0733	0.0272***	0.0882***	0.0128***	0.0407***
	(0.0240)	(0.0648)	(0.0093)	(0.0227)	(0.0038)	(0.0105)
GVC^2		−0.0676		−0.0937***		−0.0362***
		(0.0823)		(0.0329)		(0.0127)
size	0.0143	0.0141	0.0188***	0.0188***	0.0209***	0.0208***
	(0.0133)	(0.0134)	(0.0018)	(0.0018)	(0.0012)	(0.0012)
age	0.0267***	0.0266***	0.0058***	0.0058***	0.0109***	0.0108***
	(0.0078)	(0.0077)	(0.0019)	(0.0019)	(0.0021)	(0.0021)
TFP	−0.0005	−0.0004	0.0093***	0.0094***	0.0084***	0.0084***
	(0.0037)	(0.0037)	(0.0010)	(0.0010)	(0.0007)	(0.0007)
finance	0.0587	0.0609	0.0104*	0.0103*	0.0200***	0.0199***
	(0.0395)	(0.0398)	(0.0060)	(0.0060)	(0.0034)	(0.0034)
rdeff	−0.1010**	−0.1006**	0.0150	0.0147	−0.0046	−0.0045
	(0.0463)	(0.0463)	(0.0117)	(0.0117)	(0.0128)	(0.0128)
HHI	0.0024	0.0038	−0.0159**	−0.0162**	−0.0070	−0.0072
	(0.0224)	(0.0224)	(0.0071)	(0.0070)	(0.0045)	(0.0045)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
N	1617	1617	24,607	24,607	53,797	53,797
R^2	0.6990	0.6992	0.7772	0.7774	0.7982	0.7982

The values in parentheses are the standard errors clustered to the firm level. *, ** and *** indicate significant at the significance level of 10%, 5% and 1%, respectively.
Source: Authors' own calculations.

results of S.O.E.s. The findings show that G.V.C. embedment has no effect on the quality of state-owned firms' export products. The following are our thoughts on possible explanations for this phenomenon. To begin, most state-owned firms, in general, engage in industries related to the national economy, people's livelihoods, and military security. They often rely less on imported intermediate inputs to secure national security and are less likely to be monopolised by multinational businesses. Second, the internal agency costs of S.O.E.s are usually larger, and higher internal agency costs exacerbate efficiency losses. Because of these two restraints, state-owned firms have found it difficult to increase the quality of their export products by embedding in G.V.C.s.

Finally, Columns (3) through (6) shows the estimates for private and foreign-funded enterprises. The results reveal that G.V.C. embedment has greatly enhanced the quality of private and foreign-funded enterprises' export products, and the results are comparable to those of the overall firms. The influence of G.V.C. embedment on the quality of these two types of firms' export products has a 'inverted U'-type feature, but the impact of G.V.C. embedment on private enterprises is greater, and the 'inverted U' characteristic of private firms is more visible. The possible explanation for this is that, in general, foreign-funded enterprises have a background in multinational organisations, and their foreign capital background leads to a higher degree of G.V.C. embedment, and they have distinct advantages in the process of embedding in G.V.C.s. The fairer resource allocation of multinational groups on the global market makes their G.V.C. embedment quality effects on export products more consistent, and the potential inhibitory effect of G.V.C. embedment on export product quality is smaller.

3.5.2. Single-product firms vs multi-product firms

Due to diverse product strategies, the degree of firm specialisation will vary, and the firm's restricted resources will also limit the technological growth of specific products of the firm, which may result in varying quality effects of export products of G.V.C. embedment. To that purpose, we classify firms that export a H.S.-6 digit level product as single-product firms, and other firms as multi-product firms, and test the quality effect of export products of their G.V.C. embedment. Table 5 displays the results.

The estimated coefficients in columns (1) and (2) report the regression results for single-product firms, and the data in columns (3) and (4) report the regression results for multi-product firms. The results show that the G.V.C. coefficients of single-product firms and multi-product firms are both significantly positive at the 1% significance level, but the coefficient of G.V.C. of multi-product firms is larger. This shows that G.V.C. embedment has a significant impact on the quality of export products of single-product and multi-product firms, but it has a greater impact on the quality of exports of multi-product firms.

In addition, the estimated coefficients in columns (2) and (4) also show that in the process of embedding into the G.V.C.s, the quality of export products of multi-product firms faces greater potential restraint effects. On the one hand, the diversity of a firm's products is an important way to measure its product quality advantages, and

Table 5. Estimation results based on the diversity of export products.

	Single-product firms		Multi-product firms	
	(1)	(2)	(3)	(4)
GVC	0.0182***	0.0483***	0.0351***	0.0852***
	(0.0037)	(0.0100)	(0.0104)	(0.0280)
GVC^2		−0.0399***		−0.0671**
		(0.0124)		(0.0339)
size	0.0189***	0.0189***	0.0175***	0.0173***
	(0.0011)	(0.0011)	(0.0032)	(0.0032)
age	0.0054***	0.0054***	0.0047	0.0047
	(0.0014)	(0.0014)	(0.0043)	(0.0043)
TFP	0.0087***	0.0087***	0.0089***	0.0088***
	(0.0006)	(0.0006)	(0.0015)	(0.0015)
finance	0.0177***	0.0177***	0.0228**	0.0222**
	(0.0032)	(0.0032)	(0.0090)	(0.0091)
rdeff	0.0085	0.0084	−0.0071	−0.0085
	(0.0090)	(0.0090)	(0.0262)	(0.0263)
HHI	−0.0086**	−0.0087**	−0.0096	−0.0098
	(0.0039)	(0.0039)	(0.0130)	(0.0130)
Year FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
N	71,662	71,662	6,819	6,819
R^2	0.7901	0.7902	0.8692	0.8693

The values in parentheses are the standard errors clustered to the firm level. *, ** and *** indicate significant at the significance level of 10%, 5%, and 1%, respectively.
Source: Authors' own calculations.

consumers will use the diversity of products as an important clue to judge the quality of the brand's product, on the other hand, products of multi-product firms are more accessible to consumers when embedded in G.V.C.s, and their brands are more easily recognised. However, because multi-product enterprises' output range is generally broad and production concentration is relatively low, it is more difficult to ingest and absorb the high-tech inherent in imported intermediate inputs. It is also easier to achieve a technology blockade of foreign high-tech corporations against multi-product firms.

4. Conclusions and policy implication

This article conducted an in-depth investigation of the impact of G.V.C. embedment on the quality of firms' export products and the influential mechanisms using the data set obtained from A.S.I.F. and C.C.D. between 2000 and 2010. We have the following findings. First, G.V.C. embedment can greatly improve the quality of firms' export products, and the conclusion remains solid when controlling for other potential affecting factors. Second, the effect of G.V.C. embedment on the quality of firms' export products has an 'inverted U' shape. As G.V.C. embedment deepens, the quality of firms' export products displays a trend of growing and then dropping. Third, the impact of G.V.C. embedment on the quality of firms' export products is mostly due to the competitive effect and the improvement in the quality of imported intermediate inputs. Fourth, due to the heterogeneous characteristics of enterprises, the quality effect of G.V.C. embedment on export products will differ. G.V.C. embedment has a significant positive effect on the quality of export products of foreign-funded enterprises and private enterprises but has no definite effect on

S.O.E.s. G.V.C. embedment has a significant impact on improving the quality of export products of ordinary trade enterprises but has little impact on processing trade enterprises. G.V.C. embedment can significantly improve the quality of export products of both single-product and multi-product companies, but the impact on multi-product enterprises is greater.

Given that China's demographic dividend is steadily dwindling and the benefit of cheap labour no longer exists, simple price competition cannot address the objectives of firms seeking to improve their worldwide competitiveness and national economic development. As a result, improving the quality of firms' export products has increasingly become one of the directions for increasing Chinese enterprises' international competitiveness and advancing national economic development. Based on the findings of this article, we make the following recommendations.

Given that most Chinese enterprises' G.V.C. embedment is still in the process of improving the quality of their export products, we can temporarily consider promoting the upgrading of the quality of Chinese enterprises' export products by further embedding in G.V.C.s and using more high-quality imported intermediate inputs. We can, for example, deepen China's intermediate trade liberalisation and continue to advance multilateral trade agreement negotiations, particularly with developed countries, forcing developed countries to broaden their export of high-tech intermediate inputs needed by Chinese enterprises as much as possible.

The mechanism verification section of this study demonstrates that Chinese firms are currently using high-quality imported intermediate inputs to achieve the effect of G.V.C. embedment on improving the quality of their export products. To some part, this reflects the fact that the value of Chinese firms in the G.V.C. system is mostly achieved through basic assembly and production, and they have not fully digested and absorbed the technology included in imported intermediate inputs. As a result, the medium-term goal of further improving the quality of Chinese enterprises' export products is to actively promote enterprise and individual innovation in order to break through the technological monopoly of foreign multinational groups.

Notes

1. Since we cannot obtain input–output tables at the firm level, we can only assume that the proportion is 5%, based on the existing literature (Koopman et al., 2012). However, we use other ratios, such as 10%, to test the robustness. Different ratios do not affect the robustness of the conclusions in our study.
2. The preferences of the representative consumer in foreign market can be described by means of a constant elasticity of substitution (C.E.S.) utility function, in which the demand is determined by the product quality and quantity as well as the elasticity of substitution.

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