How can PFTZs affect firms' GVC positions through supply chains?

ABSTRACT Pilot free trade zones (PFTZs) is a national strategy for China's high-quality opening up. This paper analyzes the spillover effect of PFTZs on GVC positions through supply chains in China using a panel of 839 A-share listed firms from 2008 to 2016. The results show that: (1) PFTZs positively affect both upstream and downstream firms in their production line positions; (2) PFTZs improve the positions of upstream and downstream firms in GVCs by boosting productivity and overseas market performance, while also positively influencing FDI inflows to the local market; (3) The spillovers of PFTZs on upstream and downstream differ with firms' ownership, market share and location. Based on these findings, this paper advocates for a stronger focus on supply chain spillovers, including the channels and varied effects across customers, suppliers, and regions.

KEYWORDS Pilot free trade zones; Global value chains; Production line positions; Supply chains; Spillovers

1. Introduction

Integrating into the global production network, dominated by developed countries, has brought prosperity to the Chinese economy. However, China faces worsening terms of trade and increasing resource and environmental pressures due to its prolonged standing in the low value-added production stage. To cope with this structural imbalance, the Chinese government has prioritized Pilot free trade zones (PFTZs) as a key investment and national strategy. The primary task of PFTZs is high-quality opening up through institutional innovation, rather than merely promoting exports and attracting foreign investment. Developing new competitive advantages in trade through technology, branding, quality, and services, along with upgrading of processing trade and the development of new trade patterns, are crucial objectives of institutional innovation in PFTZs. Furthermore, PFTZs are dedicated to exploring replicable experiences, influencing surrounding areas and establishing a globally-oriented, high-standard free trade zone network.

Since the establishment of the Shanghai PFTZs in 2013, China has established 21 PFTZs in 56 cities in 7 rounds, spanning from the east to the west of China. PFTZs have significantly advanced China's openness and development. In 2022, the 21 PFTZs attract $33.11 billion in foreign direct investment (FDI), comprising 18.1% of China's total. Additionally, the import and export amount of PFTZs is $1.11 trillion, accounting for 17.8% of China's total. Extensive research on multi-batch pilots already confirms that PFTZs contribute to high-quality economic growth in China and enhance China's participation and position in GVCs (Chor et al., 2021; Chang and Wang, 2024; Yu et al., 2024). Thus, PFTZs offer a compelling context for studying how developing countries balance openness across domestic regions and overcome the "low-end lock-in" linked to joining GVCs dominated by developed countries (Azmeh and Nadvi, 2014).

While the positive impact and spillovers of PFTZs on economic growth has been widely discussed, there is a noticeable dispute on how PFTZs affects the opening of the surrounding area in GVCs. Is there a spillover effect of PFTZs on production line position of other regions? What mechanisms and channels might drive this effect? Research on processing trade and foreign investment suggests that the positive effects of PFTZs on GVCs are "seemingly" confined to their local regions. The annual report on PFTZs indicates that institutional innovations have led to a regional concentration of trade and foreign investment. However, few scholars have observed the positive impact of PFTZs on export growth and attracting FDI in surrounding areas (Jiang et al., 2021). Zhang and Wang (2023) even find that the establishment of PFTZs has a negative spillover effect on attracting FDI in surrounding areas. This evidence shows a "negative" impact of PFTZs on other regions in GVCs. In contrast to studies on exports and FDI, scholars have affirmed the spatial spillover effects of PFTZs on industrial structure and factor allocation. Guan et al. (2023) note that PFTZs have positive spillover effects on the service industry structure in neighboring cities. Similarly, Pan and Cao (2024) confirm that PFTZs stimulate R&D investment and the flow of technological resources, positively impacting innovation in surrounding cities. The cause of this difference is related to the underlying mechanisms of the spatial spillover

effect. The spatial spillovers rely on close transactions between agents and more efficient input-output linkages (Storper and Venables, 2004). Compared to the first two cases, industrial structure and factor allocation better reflect such close linkages between PFTZs and other regions, and therefore show more pronounced spillover effects.

Indeed, the PFTZs is encircled by numerous industrial and supply chains, which forming the foundation for input-output and transaction linkages with the surrounding areas. The Jiangsu PFTZs, for example, in 2022, provide specialized supply chain support to the biomedical industry, which resulted in a cluster of over 3800 biomedical firms, generating a total output value exceeding $35.68 billion yuan. Anhui PFTZs have implemented measures to encourage technical innovation and facilitate equipment imports, attracting over 400 firms in the integrated circuit industry and forming a complete industry chain.[1] This clustering phenomenon is also evident at the supply chain level, based on data from customers and suppliers of China A-share listed firms between 2008 and 2016. As shown in Figure 1, the top five suppliers of A-share listed firms present a distribution around PFTZs. In Figure 2, the top five customers of A-share listed firms also form a clear cluster around PFTZs. Evidence of the positive spillover effects of PFTZs at the industry level, especially in attracting industry and supply chain clusters, prompts us to investigate how PFTZs enhance GVC positions

through “chain linkages” rather than simply from geographic associations.

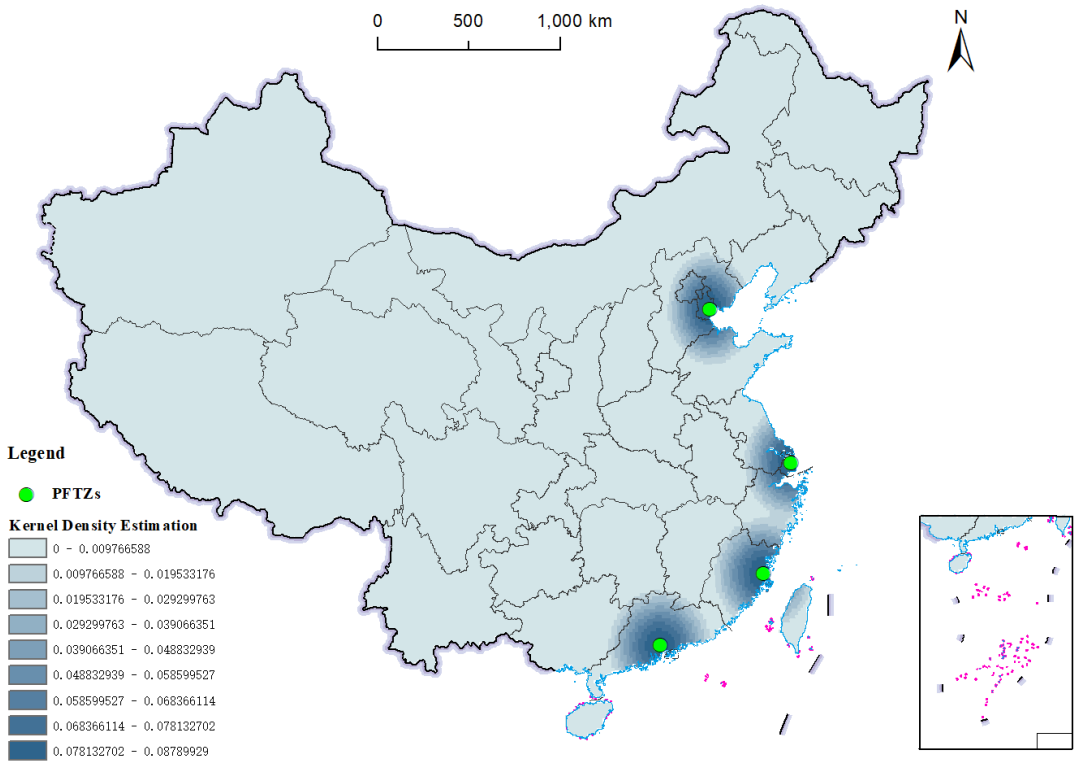

Figure 1 Distribution of top 5 suppliers of Chinese A-share listed firms from 2008-2016

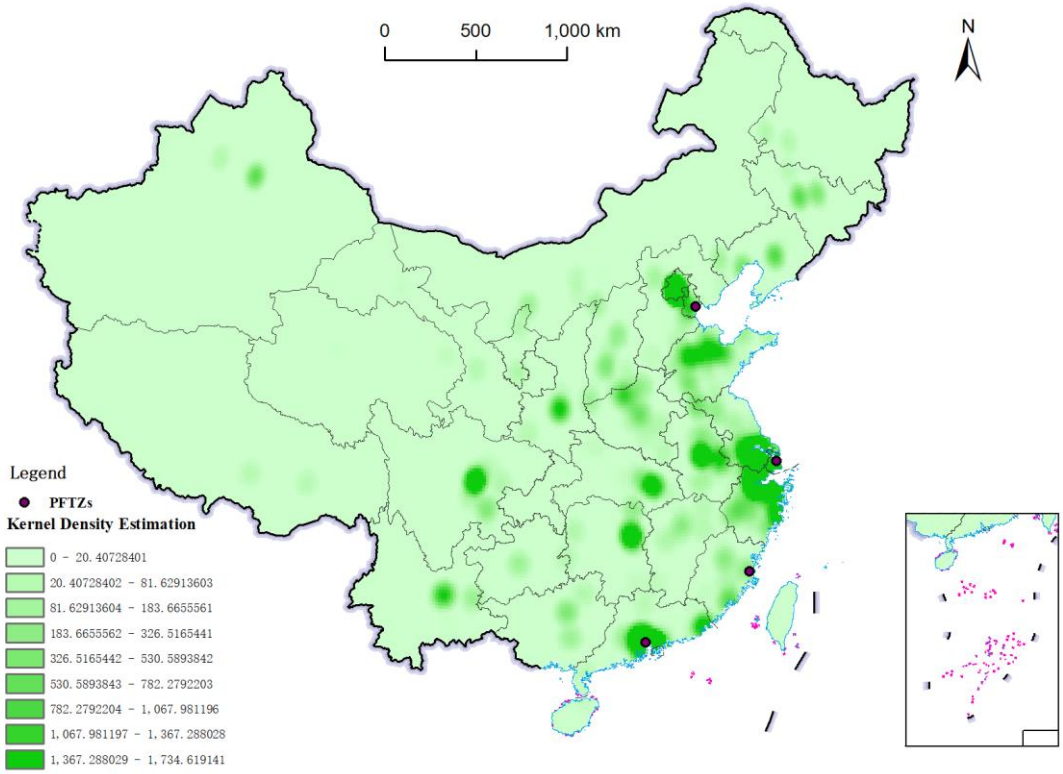

Figure 2 Distribution of top 5 customers of Chinese A-share listed firms from 2008-2016

In this context, the following points are worth exploring: (1) Do PFTZs have spillover effects on the position of upstream and downstream firms in GVCs through supply chains? (2) Does the impact of customers in PFTZs differ from that of suppliers? (3) By which channels do PFTZs influence upstream and downstream firms to adjust their position in global production lines? (4) Does the effect of PFTZs vary among different firms? We try to integrate the positive spillover effects of PFTZs and supply chains into the same analytical framework to answer above questions, utilizing a dataset of China A-share listed firms' supply chain distribution and GVC positions.

There are three possible innovations in this paper: (1) Based on firm-level supply chain transactions and GVC positions decomposition, we innovatively present empirical evidence on how supply chain trade affects GVC positions. Furthermore, the study analyses the mechanisms of firms' production stages adjustment from the dual perspective of forward and backward linkages, which extends the research in this field. (2) Unlike traditional studies focusing on the spatial spillovers of PFTZs, the study highlights the impact of PFTZs on industrial chains and supply chains. We integrate the impacts of PFTZs in supply chain cooperation and global production lines, bridging the gap in previous research on PFTZs and offering new evidence from a supply chain perspective on positive role of PFTZs in China's opening. (3) This study attempts to identify the heterogeneity in the impact of PFTZs on the GVC positions across upstream and downstream firms, various firm types, regions, and industries, which provide a more nuanced understanding on PFTZs.

2. Literature review and theoretical background

2.1. Literature review

Studies on PFTZs, spillovers in supply chains and GVCs position are closely related to our study. Firstly, the positive impacts of PFTZs are a prerequisite for our study to examine their spillover effects along supply chains. PFTZs are the pioneering zones for China's reform and opening-up, serving as experimental fields for system innovation (Yao and Whalley, 2016). Thus, PFTZs have significantly influenced China's high-quality growth and openness (Lang, 2024). Regarding high-quality growth, Fang (2020)

argues that PFTZs are important in promoting industrial upgrading, which have long outweighed the expansion of FDI and trade. Guan et al. (2023) empirically confirm that, from the perspective of spatial spillovers, PFTZs foster agglomeration economies, which in turn facilitate the upgrading of the service sector. Yang et al. (2024) conclude that the institutional innovations of PFTZs potentially promote regional innovation. In the area of openness, Bao et al. (2023) quantify the flow of foreign capital and goods in cities with PFTZs, finding that these zones can drive capital inflow and outflow. Yu et al. (2024) find that PFTZs enhance participation and upstreamness in GVCs of their cities.

Empirical analyses at the firm level offer substantial micro evidence of the positive impact of PFTZs. Chen et al. (2020) analyze how PFTZs facilitate the establishment of foreign firms, offering firm-level evidence of PFTZs' attractiveness for foreign investment. At the same time, the innovative policies implemented in PFTZs aimed at facilitating finance and trade have contributed to the agglomeration and establishment of domestic firms (Li et al., 2024). The study by Lei and Xie (2023) shows that PFTZs alleviate the financing constraints of enterprises, enabling them to engage in innovative activities driven by market competition. According to Su and Wang (2024), the impact of PFTZs extends beyond finance and also fosters innovation by promoting industrial agglomeration.

Secondly, the study of supply chain spillovers serves as the foundation for the mechanism analysis in our paper. Firms in global production networks, led by multinational corporations (MNCs), are intricately connected through supplier-customer relationships (Andrenelli et al., 2019). The data on Thai MNCs is used by Pananond (2013) to examine the spillover effect of MNCs on local firms, with participation in the global supply network facilitating their expansion into overseas markets. It has been found by Alfaro-Ureña et al. (2022) that MNCs generate spillovers to suppliers, particularly in performance improvements, enabling firms to achieve greater efficiency, higher product quality, and enhanced management experience. Ding et al. (2024) provide new evidence on the spillovers of MNCs along supply chains from trade credit and bank lending channels by analyzing supplier-customer transaction data

from Chinese firms. And numerous empirical studies confirm the spillover effects of supply chains in enhancing local market power. The study of Rozenblat et al. (2017) shows that global supply networks of MNCs interweave internal and external linkages within urban clusters. And free trade zones strengthen urban clusters. Moreover, foreign firms tend to enter urban clusters through the supply chain network. Goldman (2019) concludes in a study on government stability within supply chains that government purchases strengthen the power of the market in which firms near the supply chain are located.

Thirdly, studies on GVC positions at the firm level offer valuable insights for investigating PFTZ spillover mechanisms in supply chains. Pioneering scholars have extensively studied firms' "upgrading" within global value chains (GVCs) through numerous case studies and theoretical analyses. Ponte and Ewert (2009) and Ivarsson and Alvstam (2010) demonstrate the upgrading effects of sourcing from developed countries for local suppliers through case studies in the wine and furniture industries, respectively. Pipkin and Fuentes (2017) review earlier case studies and conclude that industry shocks and government actions, rather than customers from developed countries, primarily drive firms to upgrade within value chains.

Chor et al. (2021) propose an innovative method for measuring firm-level GVC positions by weighting sector-level input-output data with firm-level customs data. Their analysis of Chinese firms reveals that a firm's production stage advances with increases in production efficiency, size, and experience. Building on the concept of firm-level weighting, empirical evidence on firms' GVC positions has gradually expanded. In a related study, Jiang and Cheng (2023) analyze the contribution of local demand to firms' GVC positions. Hu and Della (2024) provide empirical evidence that financial constraints significantly influence firms' positions within the global production network. Furthermore, Peng et al. (2024) demonstrate that environmental regulations adversely affect the GVC positions of Chinese firms, with a pronounced impact on foreign-owned and eastern firms.

After reviewing the relevant literature, we find a deficit of research on the impact of PFTZs on firm-level GVC positions. Only a few studies focus on the spillover effects

of PFTZs in supply chains. Therefore, this paper attempts to analyze the spillovers of PFTZs on firm' GVC positions within supply chains to fill these two research gaps.

2.2. Theoretical mechanisms and research hypotheses

PFTZs in China serve as experimental fields for advancing economic openness and have been the focus of extensive policy examination. By implementing innovative policies in areas such as trade, investment, finance, and regulation, PFTZs have significantly contributed to the expansion of trade and the attraction of foreign investment. This enhances the agglomeration economy and industrial structure, generating positive spillover effects (Chen et al., 2024). In production networks, upstream and downstream firms in supply chains are interconnected through orders. Consequently, the positive spillover effects of agglomeration and industrial upgrading extend beyond the local area, reaching nearby firms through supply chain linkages (Goldman, 2019). Agglomeration economies facilitate the transfer of labor, capital, and technology to upstream and downstream firms, thereby triggering the adjustment of production lines. The upgrading of industrial structures has significantly impacted supply chain cooperation, resulting in diverse outcomes. This process enhances the global competitiveness of local firms and provides opportunities for upstream and downstream firms to advance in the global production line (Pipkin and Fuentes, 2017). Therefore, it is proposed that customers or suppliers of firms in PFTZs may facilitate their GVC upgrading.

H1: customers or suppliers in PFTZs facilitate GVC upgrading of firms.

Specifically, the positive spillovers of PFTZs on neighboring firms' operations and local market forces in supply chains are key underlying mechanisms. Firms located in PFTZs generate positive spillover effects on the productivity of upstream and downstream firms. First, the "learning-by-doing" phenomenon and the technology transfer driven by the expansion of trade and FDI are prerequisites for the efficiency spillovers associated with PFTZs (Lang, 2024). Second, a key purpose of PFTZs' preferential policies is to promote innovation, attracting clusters of innovation resources (Jiang et al., 2021). This concentration can lead to productivity spillovers from PFTZs (Zheng et al., 2017). Meanwhile, PFTZs have made significant efforts to

promote the opening of the service sector. This initiative leads to the clustering of productive service industries (Liu, Wang, and Guo, 2021). Productive service firms in PFTZs share labor, technology, and knowledge with others. And they contribute to the formation of innovation networks among firms (Yang et al., 2024). As a result, downstream customers of PFTZs not only benefit from goods and services, but also achieve technological upgrading by emulating high-quality domestic and foreign suppliers clustered in PFTZs (Abebe et al., 2022).

PFTZs significantly influence the productivity of suppliers in various ways. Suppliers benefit from direct knowledge and technology transfers from multinational production and innovation networks (Alfaro, 2017; Alfaro-Ureña et al., 2022). The demand from firms in PFTZs imposes heightened requirements on suppliers' production, compelling them to actively update their technologies. Suppliers also require substantial funding to sustain their high productivity advantages. The alleviation of financing constraints, facilitated by the aggregation of FDI attracted to PFTZs, can generate spillovers along supply chains (Ding et al., 2024). This results in PFTZs being relatively well-funded for operations and less accountable for upstream trade credit, thereby easing the financial constraints on suppliers to undertake technological upgrades. Therefore, we propose hypothesis 2:

H2: PFTZs enhance the GVC positions of both upstream and downstream firms by positively impacting their production efficiency.

Overseas operations contribute to the firms' improved GVC positions (Li et al., 2021). PFTZs are outward-oriented windows of China. The establishment of PFTZs has served not only to attract foreign firms to cluster but also to encourage quality domestic firms to actively participate in overseas markets (Lei and Xie, 2023). On the downstream side of PFTZs, firms benefit from direct technology and international standards spillovers through goods and services traded by outward-oriented suppliers in PFTZs. Firms replicate their suppliers' overseas operations and management activities in the interactions, motivating them to conduct business internationally (Buckley et al., 2002). For the upstream of PFTZs, suppliers of firms located in PFTZs

have strong internal incentives to expand overseas, beyond technology spillovers and market access. MNCs establish global production lines to benefit from low-cost suppliers for parts and assembly (Feenstra, 1998). PFTZs are one of the centers of global production networks. Firms become sub-suppliers in this production network by sourcing from firms located in PFTZs. However, remaining in low value-added and low-margin segments for an extended period does not benefit all local suppliers (Pananond, 2013). After receiving technology and access incentives from PFTZs, suppliers are actively pursuing overseas markets to enhance their market position and bargaining power. Therefore, we propose hypothesis 3:

H3: PFTZs improve upstream and downstream firms' positions in GVCs by expanding their overseas market.

Changes in FDI inflows have participants in GVC to break through the constraints of physical resource abundance, thereby facilitating strategic repositioning in GVCs (Antràs, 2020). The financial reforms implemented in PFTZs have developed a more favorable investment environment, which in turn has promoted FDI inflows and agglomeration (Bao et al., 2023). This allows FDI engage with domestic firms in supply chain networks and expand to other cities (UNCTAD, 2013; Rozenblat et al., 2017; Ding et al., 2024). The production and investment activities of MNCs are closely interconnected (Amendolagine et al., 2019). When these enterprises are attracted to specific industries, particularly within in PFTZs, they can initiate both direct and indirect transactions and interactions with other regions through industrial chain linkages. Consequently, driven by strategies aimed at cost saving and market expansion, which are the main drivers the main drivers of FDI flows, MNCs may pursue horizontal and vertical investments in relevant regions (Head and Ries, 2008). In this process, FDI clustered in PFTZs flow along supply chains to cities where upstream and downstream are located, increasing the facilitating power of local market in firms' GVC positions. Accordingly, we propose hypothesis 4:

H4: PFTZs push FDI inflows along supply chains, which encourages firms' upgrading in GVCs.

3. Data and Methodology

3.1. Sample and data sources

This paper selects Chinese A-share listed firms from 2008 to 2016 as the research sample, given the availability of firm-level supply chain, export, and import data. The data sources are Input-Output (IO) Tables from Organisation for Economic Co-operation and Development (OECD), Chinese Customs Trade Statistics (CCTS), China Urban Statistical Yearbook, China Stock Market & Accounting Research Database (CSMAR), credit investigations database from National Enterprise Credit Information Publicity System and enterprise credit investigation platforms of China.[2]

Based on the six data sources mentioned, this paper conducts the following data matching and processing: (1) Matching the financial data of Chinese A-share listed firms with their import and export data. Following the matching method of Lu et al. (2018), we match the data from CCTS with that from CSMAR using firms' names, address zip codes, and phone numbers; (2) After identifying the industry category of the firm's imports and exports, we match the IO data to Chinese A-share listed firms; (3) Gathering data on the suppliers and customers of Chinese A-share listed firms. Based on the supply chains data in the CSMAR, we collect information on the address, industry and type of suppliers and customers of Chinese A-share listed firms from the credit investigations database and platforms; (4) Matching city-level data to firms. Based on the addresses of the firms, this paper matches the China Urban Statistical Yearbook with the above dataset. Finally, we obtain the multidimensional dataset that captures the characteristics of the firm's product, supply chain, industry and city where it is located. After excluding severely missing data, ST, *ST, PT, and firms in PFTZs, this paper constructs a panel dataset of 839 Chinese A-share listed firms, comprising 2849 samples from 2008 to 2016.[3]

3.2. Description of variables

3.2.1. Dependent variable: firms' GVC positions

This paper uses an industry-level production line positions weighted by the value of the firm-level import and export to measure firms' GVC positions. As shown in formula

(1), the position index of GVCs at the industry level is the ratio of the average production length forward to the backward (Wang et al., 2017).

$$GVC\_pos = \frac{PLv_{GVC}}{[PLy_{GVC}]'} \quad (1)$$

Where PLv_{GVC} is the average production length forward, measured by the ratio of GVC related domestic value-added to its induced gross output, and PLy_{GVC} is the average production length backward, calculated as the share of GVC related foreign value-added to its induced gross output.

Furthermore, following the study of Chor et al. (2021), firm-level import and export data from the China Customs database are matched with the OECD database to calculate the share of the f firm's trade in industry i for year t. We then weight the index of average production line position in GVCs at the industry level by the share of net exports to obtain the firms' relative GVC positions. The specific method is shown as formula (2):

$$Pos_{ft} = \sum_{i=1}^{N} \frac{M_{ift}}{M_{ft}} GVC\_pos_{it} - \sum_{i=1}^{N} \frac{X_{ift}}{X_{ft}} GVC\_pos_{it} \quad (2)$$

Where M_{ift} and X_{ift} are the scale of the f firm's import and export of sector i in year t. M_{ft} and X_{ft} are the scale of f firm's total imports and exports in year t.

3.2.2. Independent variable: customers or suppliers in PFTZs

To examine the spillovers of PFTZs along supply chains, we use the independent variable indicating whether firms' customers or suppliers are in PFTZs ($Pftzs_{ft}$). In this paper, the implementation scope of PFTZs is precisely defined at the street when identifying $Pftzs_{ft}$. The specific identification process is shown below. First, we manually collect the addresses of customers and suppliers from the credit investigations database and platforms. Second, we get the latitude and longitude ranges of the implementation scope from the overall program of PFTZs published by the State Council and the planning drawings published on each PFTZs' websites. Third, using the Baidu map open platform, we convert the addresses of customers and suppliers into longitude and latitude, and determine whether they are within the implementation scope of PFTZs.

Since CCTS provides firm-level data up to 2016, our sample involves the first two batches of PFTZs established in 2013 and 2015, located in Shanghai, Guangdong, Tianjin, and Fujian. If the top five customers or suppliers are located within the Shanghai PFTZs' implementation scope from 2013, or or within the Guangdong, Tianjin, and Fujian PFTZs' implementation scope from 2015, $Pftzs_{ft}$ is 1.

3.2.3. Control variables

We control for firm-level variables that may affect firms' position in GVCs: (1) Firm scale and experience. According to Chor et al. (2021), the GVC positions of Chinese firms are higher when they are larger and more experienced. Therefore, we control for the size of assets (Scale) and age (Age), representing firm's scale and experience, respectively. The specific calculations are as follows: firm scale is determined by the logarithm of total assets; firm experience is calculated by the logarithm of the firm's accounting year minus the year of establishment. (2) Firms' financial situation. Profit is a key factor for those operating internationally (Melitz, 2003). Importantly, firms' GVCs activities, which involve multiple production stages, require substantial capital support (Manova and Yu, 2016). Therefore, we control for gross operating margin (Operating margin), return on net assets (ROA), and the firm's Debt to asset ratio to reflect firms' performance in profits and capital. (3) Corporate governance. The governance structure of firms significantly influences their decisions in GVCs trade (Lu et al., 2009). We control for the firms' board structure (Board structure), defined as the ratio of independent directors on the board.

In addition, to exclude the city-level influence of the other factors, To exclude impacts from the city level, following the study of Bao et al. (2023), we gradually include control variables of the city where the firm involved in GVCs activities is located: (1) the logarithm of GDP (GDP); (2) population scale, measured by the year-end population count; (3) industrial structure (Industry), measured by the share of secondary industry; (4) the logarithm of fiscal spending (Fiscal spending); (5) the logarithm of fixed asset investment (Investment). Table 1 presents descriptive statistics of the variables used in the estimation.

Table 1. Descriptive statistics of variables.

Variable	N	SD	Mean	Max	Min
Pos	2849	2.0801	-0.7097	7.2004	-8.4266
Pftzs	2849	0.2041	0.0435	1.0000	0.0000
Scale	2849	1.1168	21.6584	27.0345	18.8314
Age	2849	0.4068	2.5707	3.6109	0.6931
Operating	2849	0.1487	0.2458	0.9746	-0.4547
ROA	2849	0.1006	0.0401	2.6372	-2.7463
Debt to asset ratio	2849	0.2753	0.4069	7.1440	0.0080
Board structure	2849	5.3602	36.6469	100.0000	0.0000
GDP	2849	3.5252	15.5950	19.4567	4.7346
Population scale	2849	0.6791	15.4593	16.4900	11.4783
Industry structure	2849	10.8574	47.7390	89.7500	19.2600
Fiscal expenditure	2849	1.4858	24.1380	27.2627	19.4991
Investment	2849	0.8761	26.0211	27.8971	21.0069

3.3. Model settings

To verify the spillovers of PFTZs along supply chains on firms' GVC positions, we treat the presence of firms' customers or suppliers in PFTZs as a quasi-natural experiment and employ a difference-in-differences method for estimation.

$$Pos_{ft} = \alpha_0 + \alpha_1 Pftzs_{ft} + \alpha_2 Control_{ft} + \lambda_f + \mu_t + \epsilon_{ft} \quad (3)$$

Where f and t respectively represent firm f and year t. Pos_{ft} is the dependent variable indicating the GVC positions of firm f in year t. $Pftzs_{ft}$ is a dummy variable that indicates whether firm f has customers or suppliers located in PFTZs in year t. $Control_{ft}$ is a vector of control variables. λ_f and μ_t represent firm and year fixed effects. ϵ_{ft} is the random error. The coefficient α_1 of the variable $Pftzs_{ft}$ represents the spillover effects of PFTZs on firms' GVC positions along supply chains. If α_1 is significantly positive, it indicates that the segment of firm' supply chains located in PFTZs enhances its GVC positions. Conversely, the positive spillovers of

PFTZs along supply chains are not evident.

4. Demonstration results

4.1 Benchmark results

Table 2 reports the estimated results of the formula (3). Columns (1) to (3) present the results for customers or suppliers located in PFTZs. The estimation results in column (1) show that PFTZs significantly enhance the GVC positions of upstream and downstream firms. In columns (2) and (3), the coefficients of $Pftzs_{ft}$ remain significantly positive even after the stepwise addition of control variables and city fixed effect. The benchmark results from full samples indicate that PFTZs can enhance the GVC positions of Chinese firms via supply chains. To further investigate the spillovers of PFTZs along supply chains, we examine the coefficients of $Pftzs_{ft}$ within customer and supplier groups. The columns (4) to (5) show the estimation results for customers in PFTZs, and columns (6) to (7) are the estimation results for suppliers in PFTZs.

The results in columns (4)-(7) show that when with customers or suppliers in PFTZs experience significant improvements in their GVC positions. And the facilitating effect of PFTZs remains significant after accounting for city fixed effects. Comparing the coefficients of the two groups, we also find that the coefficients of the supplier group in columns (6)-(7) are significantly larger than the customer group in columns (4)-(5). The presence of firms' suppliers in PFTZs has a greater impact on the relative upstream movement of the firms during global production lines than the presence of customer in PFTZs. This implies that positive spillovers from PFTZs to downstream firms are more significant. The adjustments of the firms in GVCs activities are more pronounced when the production side is affected. On the one hand, productivity is an important factor influencing firms' activities in GVCs (Lu et al., 2018). Direct technology transfer and cooperation from suppliers improve productivity and explain the noticeable increase in firms' relative position of global production lines in the short run (Ivarsson and Alvstam, 2010). On the other hand, as analyzed in *5. Mechanism analysis* of this paper, the impact of suppliers on downstream firms in the

production network is multifaceted. This also explains the larger coefficients for the supplier group.

Table 2. Benchmark results.

	Customers or suppliers			Customer		Supplier	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Pos	Pos	Pos	Pos	Pos	Pos	Pos
Pftzs	0.5359***	0.5383***	0.5383***	0.4135**	0.4135**	0.6955**	0.6955**
	(0.1640)	(0.1663)	(0.1712)	(0.1682)	(0.1732)	(0.2901)	(0.3064)
_cons	-0.7330***	6.1933	6.1933	5.7906	5.7906	-10.1441	-10.1441
	(0.0071)	(7.2572)	(7.4702)	(7.2814)	(7.4956)	(9.6450)	(10.1852)
Controls	*No*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Year	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Firm	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
City	*No*	*No*	*Yes*	*No*	*Yes*	*No*	*Yes*
R-squared	0.6562	0.6577	0.6577	0.6580	0.6580	0.7382	0.7382
Obs.	2849	2849	2849	2843	2843	1280	1280

Notes: ***, ** and * respectively indicate the significance of results at the 1%, 5% and 10% levels. Cluster standard errors adjusted for firm level are in parentheses. Year, Firm and City respectively represent year fixed effect, firm fixed effect and city fixed effect.

4.2. Robustness test

4.2.1. Parallel trend test

The assumption of parallel trend is a prerequisite for the difference in differences method. There should be consistent trends in the treatment and control groups before assessing the impact of PFTZs. To verify this hypothesis, the following estimation model is constructed:

$$Pos_{ft} = \delta + \sum_{8}^{3} \beta_n D_{ft}^{n} + \gamma Control_{ft} + \lambda_f + \mu_t + \epsilon_{ft} \quad (4)$$

Where D_{ft}^{n} is a vector of the dummy variable representing the N-th year that the firm has customers or suppliers in PFTZs. The coefficient β_n indicates the dynamic effect of having customers or suppliers in PFTZs before and after on the firm's GVC

positions. Figure 1 presents the estimated coefficients for years -5 through 3 at 95% confidence interval with the year before (n=-1) the firm had customers or suppliers in PFTZs as the base period. It shows that each estimated coefficient is around zero when n=-5, -4, -3, -2. Before the firm's customers or suppliers are located in PFTZs, there is no significant difference in firm's GVC positions between the treatment and control group. Therefore, we conclude that the treatment and control group have parallel trend before having customers or suppliers in PFTZs. When n=0, 1, 2, 3, the coefficients are basically significant. The differences between the two groups become apparent after having customers or suppliers in PFTZs.

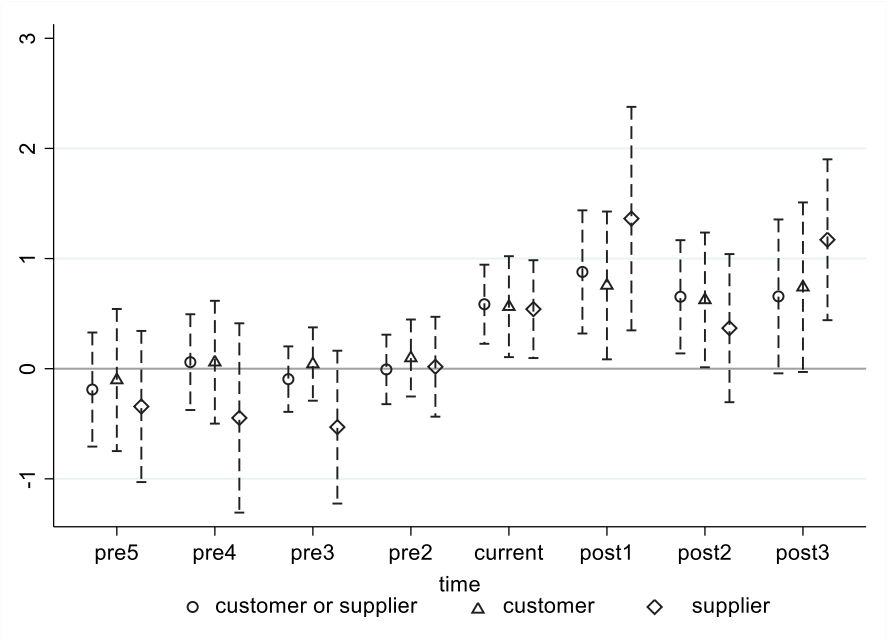

Figure 1 Parallel trend test

4.2.2. Heterogeneous Treatment Effects

Firms are affected by PFTZs at different times. And the firm's suppliers and customers change over time. This multi-period situations may lead to heterogeneous treatment effects across groups or over time when using two-way fixed-effects estimator (TWFE). And TWFE can be seriously biased due to negative weights under these heterogeneous treatment effects (Goodman-Bacon, 2021). To mitigate this bias on the results, we estimate the proportion of negative treatment effects in the sample. The estimation results show that the negative weight is only 0.09% within customers or suppliers in PFTZs. The customer and supplier groups separately with a negative weight of 0.04%

and 0.22%. This suggests a slight negative weight.

In addition, we also draw on the study of De Chaisemartin and D' Haultfoeuille (2020) to estimate the average treatment effect of having a customer or supplier that is in PFTZs using the DIDM estimator. The coefficients of $Pftzs_{ft}$ show the average total effects per treatment unit of 0.6755, 0.7707 and 0.5867 for the full sample, customer group and supplier group, which are significantly positive at the 95% level for both the full sample and customer group, and significantly positive at the 90% level for the supplier group. This result is generally consistent with the TWFE estimators. Our estimates remain robust after considering the bias due to heterogeneous treatment effects.

4.2.3. Placebo tests

To further rule out the influence of other unobservable factors on the benchmark results, we conducted a placebo test using full samples. Specifically, we construct "false" supply chain characteristics ($False_{ft}$) by randomly assigning the characteristics of customers or suppliers in PFTZs to the sample firms. After repeating this randomization process 500 times, we re-estimate the impact of the "false" dependent variable ($False_{ft}$) on firms' position in GVCs. We report the distribution of the coefficients of $False_{ft}$ in Figure 2. The estimated results in Figure 2 show that, where the distribution of the coefficients for the constructed false variable $False_{ft}$ is centred on 0, while the baseline estimates exhibit outliers in the test. This indicates that the results of the baseline regressions are not significantly influenced by unobservable factors.

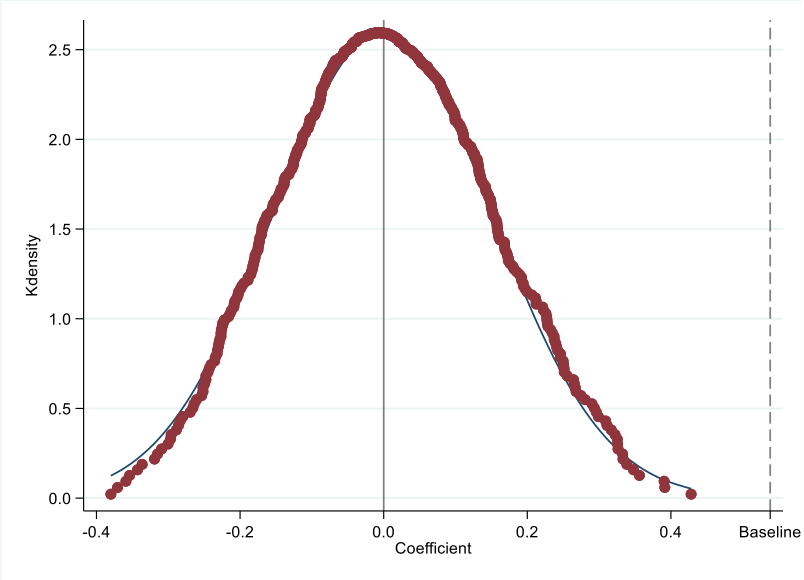

Figure 2 Placebo tests

4.2.4. Control for the impact of the Belt and Road Initiative

The Belt and Road Initiative (BRI), which was launched in 2013, is covered in the study period of this paper. The related research confirms the positive impact of the BRI on the upgrading of the countries along the route of the BRI in GVCs (Li et al., 2024). Moreover, the BRI promotes vertical integration of firms along GVCs and technological innovation (Zhang et al, 2022; Wu and Si, 2022), which will be reflected in the adjustment of firms' position in global production lines. To rule out this possibility, the cross-multiplier term (BRI_{ft}) between the cities along BRI and the proposed year of BRI (2013) is included in the baseline model. The results of the model, which includes the cross-multiplier term (BRI_{ft}), are shown in columns (1)-(3) of Table 3. Column (1) demonstrates that the coefficient of $Pftzs_{ft}$ is significantly positive and similar to the benchmark results. From the results of the customer and supplier groups, respectively, in columns (2) and (3), it can be observed that the coefficients of $Pftzs_{ft}$ in both groups are not significantly different from the baseline results presented in Table 2. Consequently, the baseline results on the positive effects of PFTZs in our study remain robust after controlling for the impact of the Belt and Road Initiative.

Table 3. Controlling the BRI and PFTZs' local impact.

	Control for the BRI impact	Control for PFTZs' local impact

	Customers or suppliers	Customer	Supplier	Customers or suppliers	Customer	Supplier
	(1)	(2)	(3)	(4)	(5)	(6)
	Pos	Pos	Pos	Pos	Pos	Pos
Pftzs	0.5195***	0.3983**	0.6888**	0.5182***	0.4038**	0.6853**
	(0.1625)	(0.1664)	(0.2871)	(0.1622)	(0.1589)	(0.3006)
_cons	7.0540	6.7065	-9.2001	8.2650	8.0485	-9.3103
	(7.2160)	(7.2434)	(9.2249)	(7.4185)	(7.4516)	(10.0799)
Controls	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Year	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Firm	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
R-squared	0.6582	0.6586	0.7384	0.6582	0.6586	0.7382
Obs.	2849	2843	1280	2849	2843	1280

Notes: ***, ** and * respectively indicate the significance of results at the 1%, 5% and 10% levels. Cluster standard errors adjusted for firm level are in parentheses. Year and Firm respectively represent year fixed effect and firm fixed effect.

4.2.5. Control for the local impact of PFTZs

PFTZs have a positive impact on the cities where they are established in terms of the business environment, innovation, and agglomeration (Yang et al., 2024). This study identifies the implementation of PFTZs at the street-level, which means that firms in the cities with PFTZs remain included in the benchmark estimation sample. The spillovers along the supply chain in the benchmark estimation may be confounded by this positive effect of PFTZs on cities. To mitigate the local impact of PFTZs on the results, we exclude the samples from the cities with PFTZs and re-estimate PFTZs' spillover effect ($Pftzs_{ft}$) along supply chains. The results are shown in columns (4)-(6) of Table 3. The study finds that the coefficients of $Pftzs_{ft}$ are still significantly and show virtually no difference from the baseline results. The local impact of PFTZs does not significantly affect our benchmark estimates. This reaffirms that the effect of having customers or suppliers located in PFTZs on firms' position in GVCs is robust.

4.2.6. Endogeneity

Another potential issue for this paper is the reverse causal relationship between the Customer or supplier in PFTZs and firms' GVC positions. The firm's production line location may influence its choice of customers or suppliers. Faced with policy incentives, quality customers and suppliers cluster in PFTZs. Firms located relatively closer to upstream side in GVCs may prefer to cooperate with high-quality customers and suppliers in PFTZs to maintain their high value-added advantage. To alleviate such endogeneity problems, the benchmark model is re-estimated using the traditional instrumental variables and the heteroskedasticity instrumental method.

We first construct instrumental variables $Distance_{ft}$ using the average distance of customers and suppliers from the firm's location. The distance from customer and supplier to the firm will not directly affect the firm's GVC positions. However, the distance between the two may affect a firm's choice of customers or suppliers due to transportation costs. Therefore, we consider $Distance_{ft}$ to be a valid instrumental variable. Referring to Lewbel (2012), we used heteroskedasticity to construct another instrumental variable $(Z_f - \bar{Z})\epsilon$. We then construct instrumental variables through multiplying the residuals (ϵ) of the regression with the endogenous and exogenous variable by a set of exogenous variables of the model after decentralization ($Z_f - \bar{Z}$). Considering that population, fixed asset investment and fiscal expenditures in cities are less directly affected by endogenous variables, we choose these three control variables in the model as Z_f. The results of the two-stage least squares estimation using instrumental variables are shown in Table 5. The results in columns (1)-(6) show that the coefficient of $Pftzs_{ft}$ is still significantly positive when considering the endogeneity. In addition, we report the results of the tests for the instrumental variables in Table 4. The Kleibergen-Paap rk LM estimator rejects the hypothesis of underidentification. The Cragg-Donald Wald F and Kleibergen-Paap rk Wald F statistics also reject the hypothesis of weak instrumental variables. This again suggests that the positive effects of customers or suppliers in PFTZs on firms' GVC positions in the baseline results is robust.

Table 4. Regression results using the instrumental variable method.

	IV1：Distance			IV2: $(Z_f - \bar{Z})\epsilon$		
	Customer or supplier	Customer	Supplier	Customer or supplier	Customer	Supplier
	(1) Pos	(2) Pos	(3) Pos	(4) Pos	(5) Pos	(6) Pos
Pftzs	8.9956***	12.7507**	7.3963**	1.1062***	0.4629*	0.9348*
	(3.3503)	(5.2816)	(3.3335)	(0.3652)	(0.2485)	(0.5417)
Kleibergen-Paap rk LM	18.078	12.341	11.293	34.354	23.394	13.789
	(0.0000)	(0.0004)	(0.0008)	(0.0000)	(0.0001)	(0.0080)
Cragg-Donald Wald F	25.780	16.597	20.351	101.977	98.731	94.082
Kleibergen-Paap rk Wald F	19.463	12.597	14.683	15.888	10.703	22.560
Controls	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Year	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Firm	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Obs.	2670	2664	1102	2849	2843	1280

Notes: ***, ** and * respectively indicate the significance of results at the 1%, 5% and 10% levels. Cluster standard errors adjusted for firm level are in parentheses. Year and Firm respectively represent year fixed effect and firm fixed effect.

5. Mechanism analysis

In this section, we analyze the mechanisms behind the positive effect of having customers or suppliers in PFTZs. We propose triple channels of positive spillovers from PFTZs along supply chains. Firstly, the promotion effect of PFTZs on technological innovation and business globalization is obvious (Bao et al., 2023; Yang et al., 2024). A series of preferential policies in PFTZs have attracted the clustering of innovative resources and foreign enterprises. These agglomeration phenomena impact supply chains within PFTZs, influencing both upstream and downstream along the inter-firm orders. This enhances production efficiency and expands overseas markets for upstream and downstream firms. Technological progress-driven cross-border production

collaboration is a key aspect of GVCs (Antràs, 2020). Higher productivity efficiency and greater cross-border market experience explain their relative upstream positions in global production lines (Chor et al., 2021). Secondly, foreign direct investment (FDI) from MNCs is a key component of globalized production (Adarov and Stehrer, 2021). FDI inflows to developing countries accompanied by capital and technology along with capital and technology, help extend production lines and support their advancement to upstream (Amendolagine et al., 2019; Rahman et al., 2024). PFTZs' exploration on investment facilitation attracts significant inflows of FDI (Lang, 2024). This may also have a positive spillover along the supply chains in attracting foreign investment to nearby regions, which in turn facilitates the "upgrading" of firm' GVC positions.

To explore the spillover mechanism of PFTZs along the supply chains to upstream and downstream firms, the estimation model is constructed as following:

$$Channels_{ft} = \theta_0 + \theta_1 Pftzs_{ft} + \theta_2 Control_{ft} + \lambda_f + \mu_t + \epsilon_{ft} \quad (5)$$

Where $Channels_{ft}$ is the mechanism variable, θ_0 is the constant term, and θ_1 is the coefficient of the independent variable $Pftzs_{ft}$, which represents the effect of PFTZs along the supply chains on the mechanism variable.

5.1. Production efficiency channel

The constraint of firms' productivity on their selection of higher value-added segments in the global production line is primitive (Manova and Yu, 2016). Efficient outputs ensure firms remain financially and technically competitive, determining their position within global supply chains. Thus, higher productivity therefore, accounts for the integration of the firms into higher value added and relatively upstream position in the global production line. Consequently, this paper considers the spillover effect of PFTZs in production efficiency as a contributing factor to the improvement of the firms' positions in GVCs.

We measure the productivity efficiency of the firms by calculating total factor productivity (TFP) using the FE and OP methods respectively (TFP_FE_{ft} and TFP_OP_{ft}). The results in Table 5 confirm the spillover mechanism of PFTZs regarding production efficiency. The estimation results in columns (1)-(3) show that the

coefficient θ_1 of $Pftzs_{ft}$ on suppliers in PFTZs is significantly positive, but the estimated coefficient θ_1 of $Pftzs_{ft}$ on customers in PFTZs is not significant. In comparison to customers in PFTZs, suppliers in PFTZs exert more significant positive spillover effects on the productivity of downstream firms. The estimated coefficient of $Pftzs_{ft}$ on TFP_OP_{ft} in column (6), which demonstrates the spillovers of PFTZs in supplier groups, further confirms this phenomenon. That is, the spillover effects of PFTZs on production efficiency incentives are more significant for downstream firms compared to upstream. Firms can more effectively gain productivity benefits from products and services from suppliers in PFTZs.

Table 5. Productivity efficiency channel.

	Customer or supplier	Customer	Supplier	Customer or supplier	Customer	Supplier
	(1)	(2)	(3)	(4)	(5)	(6)
	TFP_FE	TFP_FE	TFP_FE	TFP_OP	TFP_OP	TFP_OP
Pftzs	0.0271	-0.0075	0.1022**	0.0414	-0.0082	0.0906*
	(0.0346)	(0.0416)	(0.0518)	(0.0356)	(0.0423)	(0.0501)
_cons	- 5.2586***	-5.2127***	10.9669***	-0.7251	-0.6460	6.3670***
	(1.7783)	(1.7640)	(0.0041)	(1.5111)	(1.5072)	(0.0043)
Controls	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Year	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Firm	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
R-squared	0.9820	0.9820	0.9840	0.9489	0.9488	0.9566
Obs.	2496	2491	1136	2496	2491	1136

Notes: ***, ** and * respectively indicate the significance of results at the 1%, 5% and 10% levels. Cluster standard errors adjusted for firm level are in parentheses. Year and Firm respectively represent year fixed effect and firm fixed effect.

5.2. Overseas Market Channel

The expansion of firms in overseas markets also accounts for the movement of firms to relatively upstream positions. Entering new markets not only brings new orders to firms, but also new opportunities for upgrading (Yeung and Coe, 2015). This paper argues that

the overseas markets influence firms' production positions within GVCs in both directions. On the one hand, engaging in overseas markets through competition and cooperation offers domestic firms opportunities for technological advancement, thereby encouraging a shift towards high value-added segments. On the other hand, the expansion of firms in overseas markets strengthens their linkages with global trade networks and helps firms to establish more convenient and less costly trade networks, ultimately improving firms' control over where they are in the supply chain globally (Li et al, 2021). As a result, firms pursuing higher margins and bargaining power actively shift their global production to more value-added upstream stages. Therefore, the expansion of overseas markets, driven by PFTZs spillovers to upstream and downstream firms, is a potential mechanism for firms' upgrading in GVCs.

We measure firms' overseas market performance using two metrics: the number of countries (or regions) involved in a firms' overseas business ($Overseas\_m_{ft}$) and the ratios of a firms' overseas business revenue ($Overseas\_r_{ft}$). Considering that firms' access to overseas markets is deeply constrained by their financial status and Market position, we further control for firms' liquid assets share, price-earnings ratio, and owner's equity as a percentage of industry market share when estimating spillovers of PFTZs along supply chains. Table 6 displays the estimation results for the overseas market channel. The results in columns (1) and (4) indicate that supply chain segments in PFTZs significantly boost the revenue and operational scope in overseas markets. Comparing the results for the customer group in columns (2) and (5) with the supplier group in columns (3) and (6) reveals that the firms with suppliers in PFTZs experience a more notable increase in the profitability of overseas markets. And customers in PFTZs significantly affect the scope of their suppliers' overseas market operations.

The possible explanations are that PFTZs serve as platforms connecting domestic and foreign markets. Unlike the indirect demand from customers located in PFTZs, goods and services from suppliers in PFTZs have a direct impact on the firm's production abroad, which is directly reflected in the firm's revenue. Compared to suppliers in PFTZs, the firm with customers in PFTZs not only gain valuable experience and technology from these zones but are also motivated to expand their reach beyond

serving customers within PFTZs to entering overseas markets. Unlike those with suppliers in PFTZs, they are driven by the desire to higher bargaining and leadership power. Consequently, firms with customers in PFTZs often seek to transcend the limitations of serving a restricted number customers and try to expand their markets aiming to achieve competitive advantage in global production.

Table 6. Overseas market channel.

	Customer or supplier	Customer	Supplier	Customer or supplier	Customer	Supplier
	(1)	(2)	(3)	(4)	(5)	(6)
	Overseas_r	Overseas_r	Overseas_r	Overseas_m	Overseas_m	Overseas_m
Pftzs	0.1137*	0.1203*	0.2707*	0.0393***	0.0490***	0.0169
	(0.0584)	(0.0711)	(0.1611)	(0.0141)	(0.0146)	(0.0244)
_cons	0.4149	0.2761	-2.6278	-0.0651	-0.0741	1.6109
	(3.5030)	(3.5066)	(7.6827)	(1.1248)	(1.1271)	(1.54)
Controls	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Year	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Firm	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
R-squared	0.9014	0.8718	0.8720	0.9246	0.9247	0.9455
Obs.	1593	1590	696	1593	1590	696

Notes: ***, ** and * respectively indicate the significance of results at the 1%, 5% and 10% levels. Cluster standard errors adjusted for firm level are in parentheses. Year and Firm respectively represent year fixed effect and firm fixed effect.

5.3. FDI channel

FDI is one of the ways in which MNCs organize their global production lines (Hoekman and Sanfilippo, 2023). The relocation of MNC production lines, along with FDI inflows, boosts the sourcing of local inputs (Hanousek et al., 2017). While providing opportunities for local factories to join global production networks, this also allows local suppliers to reap the benefits from sourcing that facilitates technology and capital transfers as well as economies of scale (Hanousek et al., 2011; Javorcik, 2014). Consequently, this spillover triggers product upgrading and technological innovation

in local firms, propelling them towards higher value-added upstream activities. Therefore, we consider the spillover effect of PFTZs along the supply chains on FDI in the regions where the upstream and downstream firms are located as the potential mechanism.

We analyze how supply chain segments in PFTZs affect both the amount ($FDI1_{ft}$) and the share ($FDI2_{ft}$) of FDI in the cities hosting upstream and downstream firms.[4] Table 7 presents the results for the FDI channel. The results of $FDI1_{ft}$ in columns (1)-(3) suggest that cooperation along the supply chains in PFTZs positively affects FDI. Moreover, PFTZs primarily boost FDI inflows through the cooperation between suppliers in PFTZs and downstream firms. The spillover effect on FDI is less evident in the upstream of PFTZs. The estimation results of columns (4)-(6) of $FDI2_{ft}$ are consistent with the results of $FDI1_{ft}$. The presence of suppliers in PFTZs significantly boosts the share of FDI in the region where the firms are located, reinforcing the previous conclusions.

Table 7. FDI channel.

	Customer or supplier	Customer	Supplier	Customer or supplier	Customer	Supplier
	(1)	(2)	(3)	(4)	(5)	(6)
	FDI1	FDI1	FDI1	FDI2	FDI2	FDI2
Pftzs	0.0821*	0.0433	0.1308**	0.0012	0.0002	0.0043*
	(0.0422)	(0.0531)	(0.0586)	(0.0016)	(0.0020)	(0.0023)
_cons	-0.8558	-0.8054	-9.7134	0.0879	0.0896	0.2140
	(5.5244)	(5.5394)	(11.4884)	(0.0598)	(0.0605)	(0.1326)
Controls	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Year	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Firm	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
City	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
R-squared	0.9654	0.9653	0.9631	0.9684	0.9684	0.9658
Obs.	2788	2782	1250	2788	2782	1250

Notes: ***, ** and * respectively indicate the significance of results at the 1%, 5% and 10% levels.

Cluster standard errors adjusted for firm level are in parentheses. Year, Firm and City respectively represent year fixed effect, firm fixed effect and city fixed effect.

6. Heterogeneity analysis

6.1. Ownership

Firms with distinct ownership structures clearly demonstrate differences in their operating strategies. As a result, they are affected by PFTZs in varying ways. To determine the differential spillover effects of PFTZs based on ownership, the sample is divided into state-owned enterprises (SOEs) and non-state-owned enterprises (non-SOEs). Table 8 presents the estimation results concerning ownership heterogeneity. The estimation results in columns (1) and (4) show that the coefficients of $Pftzs_{ft}$ are significantly smaller in the non-SOEs group. The supply chain segments in PFTZs exert a more pronounced facilitating effect on SOEs. Furthermore, a comparison between the results in columns (2) with those in columns (5) reveals a similar conclusion. However, the coefficient in column (6) is not significant. SOEs are less affected by the impact from suppliers in PFTZs than non- SOEs.

In China, SOEs are tasked with optimizing the structure and layout of the economy, in contrast to non-SOEs that operate for profit. SOEs are not only demonstrably influenced by a series of guidance policies on the supply chains from PFTZs, but also are responsible for implementing government policy. This explains the greater exposure of SOEs to the spillovers of PFTZs in general. The differing significance of SOEs and non-SOEs in the supplier group likely results from firm characteristics and the spillover effects of PFTZs. Overseas Markets serve as the channel through which PFTZs affect upstream suppliers. TFP is the primary channel for influencing the firm with suppliers in PFTZs. And SOEs gain supports from the government, with the objective of fostering the emergence of world-class enterprises. Therefore, compared to efficiency mechanisms, the SOEs is more susceptible to Overseas Markets mechanisms. SOEs with customers in PFTZs are more active in expanding overseas, which means that the spillover effects of PFTZs on upstream are greater impact in SOEs. And suppliers in PFTZs contribute more significantly to the upstream movement of non-SOEs in GVCs.

Non-SOEs may be more proactive than policy-supported SOEs in achieving efficiency gains from their suppliers' products and services.

Table 8. Heterogeneous effects of ownership.

	Non-SOEs			SOEs		
	Customer or Supplier	Customer	Supplier	Customer or Supplier	Customer	Supplier
	(1)	(2)	(3)	(4)	(5)	(6)
	Pos	Pos	Pos	Pos	Pos	Pos
Pftzs	0.4669**	0.3927*	0.5599**	0.6405**	0.4803*	1.1556
	(0.1932)	(0.2252)	(0.2675)	(0.3059)	(0.2670)	(0.8401)
_cons	13.6025	12.9288	-18.5472	-7.026	-7.0923	-13.6787
	(10.7651)	(10.8023)	(16.2375)	(11.9839)	(12.1055)	(26.1670)
Controls	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Year	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Firm	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
R-squared	0.6200	0.6210	0.7129	0.7267	0.7256	0.8147
Obs.	1796	1790	855	1035	1035	414

Notes: ***, ** and * respectively indicate the significance of results at the 1%, 5% and 10% levels. Cluster standard errors adjusted for firm level are in parentheses. Year and Firm respectively represent year fixed effect and firm fixed effect.

6.2. Industry concentration

The behavior and performance of firms involved in GVCs activities are sensitive to the industry concentration, which reflects market competition. Therefore, the spillovers from the supply chains may have a heterogeneous impact across industries with different levels of concentration. To assess heterogeneous spillovers from PFTZs across industry concentrations, we use the Herfindahl-Hirschman index (HHI), based on firms' revenue, to divide the sample into two groups. The study observes the coefficients of $Pftzs_{ft}$ for groups above and below the median of HHI. The results of the heterogeneity of the spillovers from PFTZs across industry concentration are shown in Table 9. Comparing the coefficients of $Pftzs_{ft}$ in columns (1) and (4), we find that

PFTZs have a more pronounced effect along supply chains in industries with lower concentration. This finding is further supported by grouping suppliers and customers presented in columns (2)-(3) and (5)-(6). Firms in less concentrated industries benefit from increased market competition. They excel in efficiency and profitability, supporting firms' shift to higher value-added segments in global production lines.

Table 9. Heterogeneous effects of industry concentration.

	High			Low		
	Customer or Supplier	Customer	Supplier	Customer or Supplier	Customer	Supplier
	(1)	(2)	(3)	(4)	(5)	(6)
	Pos	Pos	Pos	Pos	Pos	Pos
Ftz	0.4548***	0.4321**	0.5111*	0.6395**	0.4663*	0.9416**
	(0.1680)	(0.2137)	(0.2764)	(0.2726)	(0.2738)	(0.4504)
_cons	18.4671*	18.1676	-0.3545	-30.2466	-29.3454	-66.0354
	(10.0854)	(10.2231)	(12.9601)	(19.5673)	(19.4668)	(46.4158)
Controls	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Year	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Firm	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
R-squared	0.6925	0.6928	0.7738	0.6902	0.6909	0.7551
Obs.	1481	1478	640	1364	1361	640

Notes: ***, ** and * respectively indicate the significance of results at the 1%, 5% and 10% levels. Cluster standard errors adjusted for firm level are in parentheses. Year and Firm respectively.

6.3. Region

Considering the differences in the development of economy, business environment and industrial fundamentals across different regions in China, we analyze the regional heterogeneity on the firms' GVCs position by dividing the sample into two groups, Eastern and Midwestern, based on the firms' geographic location. Table 10 demonstrates the heterogeneous impact of the supply chains segment in PFTZs on firms located in the Eastern and Midwestern regions. A comparison of the estimation results in columns (1) and (4) reveals that the promotive effect of customers or suppliers being

in PFTZs on GVCs position is greater for firms in the eastern region. Comparing columns (2)-(3) with columns (5)-(6), both customers and suppliers in PFTZs generate more significant spillovers to firms in the Eastern than in the Midwest. The East of China benefits from a more favorable geographical location, superior infrastructure, greater openness, and stronger industrial agglomeration compared to the Midwest. In the face of the positive spillovers of PFTZs, firms in the eastern region are actively adjusting to the upstream in global production lines, which is supported by the advantageous resources from the region.

Table 10. Heterogeneity across different regions.

	Eastern			Midwestern		
	Customer or Supplier	Customer	Supplier	Customer or Supplier	Customer	Supplier
	(1)	(2)	(3)	(4)	(5)	(6)
	Pos	Pos	Pos	Pos	Pos	Pos
Pftzs	0.8016***	0.6817***	0.7608**	0.0359	0.0134	0.2169
	(0.2277)	(0.2448)	(0.3750)	(0.1719)	(0.1916)	(0.1374)
_cons	-5.5723	-6.3575	-37.9267	4.439	4.4269	-7.0740
	(14.3202)	(4.2041)	(23.9910)	(11.9155)	(12.0315)	(12.7052)
Controls	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Year	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Firm	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
City	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
R-squared	0.6482	0.6480	0.7199	0.6996	0.6993	0.8027
Obs.	2009	2005	897	840	838	383

Notes: ***, ** and * respectively indicate the significance of results at the 1%, 5% and 10% levels. Cluster standard errors adjusted for firm level are in parentheses. Year, Firm and City respectively represent year fixed effect, firm fixed effect and city fixed effect.

7. Conclusions and implications

7.1. Conclusions

This paper empirically analyzes the impact of PFTZs on the GVC positions of upstream and downstream firms. The study finds that the customers or suppliers in PFTZs explains the movement of firms to relative upstream in GVCs. This promotional effect remains robust to the exclusion of chance, heterogeneous treatment effects, other policy influences, and endogeneity. Customers in PFTZs drive the expansion of firms in overseas markets, which in turn facilitates the rising of their GVC positions. Increased productivity, overseas revenues of downstream firms, and the inflow of FDI into the local market are the mechanisms behind the positive effects of suppliers in PFTZs. Heterogeneity of supply chain segments in PFTZs for firms with different ownership, market share and region.

7.2. Implications

First, governments should focus on the spillover effects of policies along supply chains. The outcomes of the policy can be translated and absorbed not only through learning between surrounding governments. The positive effects of incentive-based policies are also evident in upstream and downstream regions and firms along supply chains. Therefore, the spillovers of supply chains deserve to be noticed. Second, the mechanisms of interaction between supply chain partners are worth exploring. The impact of supply chain partners extends beyond mere profitability in sales. The high-quality customers and suppliers exert multiple influences on upstream and downstream. How positive and negative impacts are transmitted between supply chains still deserves deeper analysis. Third, it is essential to focus on the heterogeneity triggered by firms' differences in ownership, size and location. While exploring ways to maintain the competitiveness of dominant enterprises, it is also important to actively seek solutions to promote non-SOEs, and ensure balanced development of regions to inject new vitality into economic growth.

Notes

1. The data on foreign trade, foreign investment, and industry chains and supply chains in PFTZs are from the China Pilot Free Trade Zone Development Report (2023) that is published by Chinas' Ministry of Commerce on November 06, 2022.
2. The addresses of customers and suppliers of the firm are sourced from credit investigations

database of National Enterprise Credit Information Publicity System and notable platforms, like qcc.com and tianyancha.com.

3. We refine the scope of PFTZs to the street level in eliminating firms located in the first-two-batches PFTZs. Also considering the impact of the planning for the upcoming PFTZs on its cities, we exclude firms located in the cities where the last-five-batches PFTZs.
4. The amount of FDI of the city where the firm f is located $FDI1_{ft}$ is the logarithm of the amount of foreign investment actually used by the city in the year t. The source of data is the China Urban Statistical Yearbook of the Department of Urban Social and Economic Survey of the National Bureau of Statistics. The share of FDI ($FDI2_{ft}$) amount citywide for the year is city's share of the national amount of actual use of foreign capital. Data on FDI at the national level are from the China Statistical Yearbook of the National Bureau of Statistics.

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