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Impact of Supply Chain Digitalization on Total Factor Productivity of Manufacturing Export Enterprises in Guangdong Province

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Abstract

Against the backdrop of deepening global digital economy and intensifying competition in industrial and supply chains, supply chain digitalization has become a key lever for manufacturing export enterprises to hedge external risks and cultivate competitive advantages. As China's leading manufacturing and foreign trade province, Guangdong hosts export-oriented manufacturers deeply embedded in global value chains. This study uses panel data from 308 A-share listed manufacturing firms in Guangdong with export operations between 2012 and 2024. Leveraging the 2018 pilot policy on supply chain innovation and application as a quasi-natural experiment, we employ a difference-in-differences model and the Levinsohn-Petrin method to estimate total factor productivity. Mediating mechanisms are examined through technological innovation, operational efficiency, and transaction costs. Results show that supply chain digitalization significantly enhances productivity, with stronger effects among larger exporters, Pearl River Delta firms, and high-tech manufacturers.

Keywords

Supply Chain Digitalization; Total Factor Productivity; Manufacturing Export Enterprises; Quasi-Natural Experiment; Guangdong Province

1. Introduction

With the rapid advancement of digital technology and the deepening of economic globalization, global competition has evolved from firm-level rivalry into competition over the integration capacity of industrial and supply chain networks. China's 14th Five-Year Plan emphasizes building more innovative, value-added, and secure industrial and supply chains. Guangdong Province, as the nation's largest economy and foreign trade hub, has continuously ranked first in GDP, industrial value added, and total import-export volume for over three decades, forming competitive clusters in electronics, electrical machinery, and related sectors [1].

Since 2018, the Ministry of Commerce and other agencies have issued successive

policies on supply chain innovation and application pilots, explicitly promoting supply chain digitalization and intelligent development. However, given the high-risk, high-investment, and high-return characteristics of supply chain digitalization, its impact on firm-level TFP remains uncertain. Existing studies have examined digitalization's economic effects and TFP determinants, yet research specifically targeting Guangdong manufacturing export enterprises remains limited [2-4]. Accordingly, this paper focuses on the following three questions: (1) Does supply chain digitalization significantly improve TFP among Guangdong manufacturing export firms? (2) Through what mechanisms does this effect operate? (3) Does the effect vary across regions, ownership types, and industry categories?

The main contributions of this paper include: first, focusing on export-oriented manufacturing firms in Guangdong to fill a regional research gap; second, constructing a DID framework based on the 2018 supply chain pilot policy and applying the LP method for TFP estimation; third, systematically testing innovation, operational efficiency, and transaction cost as mediating channels, and examining heterogeneity across regions and industries.

2. Research Design and Methods

This study adopts a combined approach of quasi-natural experiment identification and panel data econometrics, with the following steps.

(1) Sample selection. The sample comprises 308 A-share listed manufacturing companies in Guangdong with export operations from 2012 to 2024. Firms in the financial sector, ST/*ST/PT firms, and observations with missing core variables are excluded. Continuous variables are winsorized at the 1st and 99th percentiles.

(2) Identification strategy. Following Zhang et al. (2021) and Liu et al. (2023), the 2018 Supply Chain Innovation and Application Pilot Policy is treated as an exogenous shock. A treatment group dummy (Treat = 1 for pilot firms) and a post-policy time dummy (Time = 1 for 2018 and thereafter) are interacted to form the core explanatory variable (Did = Treat × Time).

(3) TFP estimation. The LP semi-parametric method is employed to estimate firm TFP, using intermediate inputs as proxy variables to address simultaneity bias and sample selection issues inherent in OLS and OP methods [5].

(4) Model specification. The baseline DID model controls for firm and year fixed effects. Mediation models follow Wen et al. (2014) to test innovation, operational efficiency, and transaction cost channels. Financial data are sourced from CSMAR and Wind databases.

Table 1. Main variable definitions.

Variable Type	Variable	Symbol	Definition
Explanatory	Supply Chain Digitalization	Did	Treat × Time interaction term
Dependent	Total Factor Productivity	TFP	Estimated via LP method
Mediator	Innovation	Patents	Ln(1 + total patent applications)
Mediator	Operational Efficiency	TAT	Revenue / average total assets

Mediator	Transaction Cost	Analysts	Number of analyst followers
Control	Firm Size	Size	Ln(total assets)
Control	Leverage	Lev	Total liabilities / total assets
Control	ROA	Roa	Net profit / total assets

3. Current Status and Problem Analysis of Supply Chain Digitalization in Guangdong

As China's largest manufacturing and foreign trade province, Guangdong occupies a pivotal position in the global value chain. Against the backdrop of the digital economy and supply chain restructuring, examining the current state of supply chain digitalization and total factor productivity (TFP) among export-oriented manufacturing firms is essential for understanding the micro-foundation of high-quality foreign trade development. Based on provincial statistical data, industry reports, and the 2012–2024 panel sample used in this study, this section analyzes development trends and structural constraints from three dimensions: digitalization progress, productivity performance, and their coordinated evolution (see Table 2).

Table 2. Core economic indicators of Guangdong Province, 2020–2024.

Indicator	2020	2021	2022	2023	2024
GDP (trillion CNY)	11.1	12.4	12.9	13.6	12.9
Industrial Value Added (trillion CNY)	3.3	3.7	3.8	3.9	4.0
Total Import-Export (trillion CNY)	7.1	8.3	8.3	8.0	8.3
National Ranking (GDP & Trade)	1	1	1	1	1

3.1. Development Status of Supply Chain Digitalization

Driven by provincial digital transformation policies and the 2018 national supply chain innovation pilot program, Guangdong's export manufacturing sector has entered a phase of accelerated digital upgrading. By 2024, more than 20,000 scaled industrial enterprises had implemented digital transformation, and over 500 industrial internet platforms had been established, ranking among the highest nationwide. The province's digital economy exceeded 6 trillion CNY, accounting for more than 47% of GDP, providing a relatively strong infrastructure base for supply chain digitalization.

However, digitalization progress exhibits pronounced stratification across firms. Large technology-intensive exporters have integrated digital links across production, sales, cross-border logistics, and customer management, enabling real-time coordination and data-driven decision-making. By contrast, many labor-intensive small and medium-sized export firms remain at the stage of basic online order processing and inventory recording, with insufficient investment in supply chain systems integration. Intra-cluster digital collaboration is relatively advanced in electronics and electrical machinery agglomerations, yet cross-border supply chain data remain fragmented, limiting the transmission of digitalization benefits across overseas clients, local manufacturers, and upstream suppliers.

From a regional perspective, the Pearl River Delta concentrates the bulk of digital platforms, industrial software vendors, and export-oriented smart factories, whereas firms in eastern and western Guangdong still rely heavily on traditional offline coordination. From an industry perspective, digitalization rates exceed 85% in electronics, high-end equipment, and modern logistics, but remain near 59% in textiles, general chemicals, and raw material processing. This uneven pattern suggests that supply chain digitalization in Guangdong is broad in coverage but uneven in depth.

3.2. Development Status of TFP among Export Firms

TFP is a core indicator of whether export firms can maintain competitive advantages under rising labor costs and external trade uncertainty. Based on the LP method and the sample described in Section 2, Guangdong manufacturing export firms show significant heterogeneity in productivity performance. Leading firms with larger export scale and stronger R&D capacity generally achieve higher and more stable TFP growth, while a large number of small and medium-sized firms remain trapped in low-value assembly and standardized manufacturing, with limited efficiency gains.

At the macro level, Guangdong's industrial competitiveness continues to improve, as reflected in the steady expansion of industrial value added and the province's sustained national leadership in foreign trade shown in Table 2. At the micro level, sample firms differ substantially in output scale, capital intensity, and intermediate input efficiency, indicating a highly skewed firm-size distribution. Such heterogeneity implies that productivity improvements are unlikely to occur uniformly; rather, they depend on firms' ability to combine digital tools with organizational upgrading and innovation.

During the 14th Five-Year Plan period, manufacturing TFP growth nationwide has slowed to around 1% annually, compared with more than 2% during the 13th Five-Year Plan period. For export firms in Guangdong, productivity growth is increasingly constrained by weak technology conversion, insufficient collaborative innovation, and resource misallocation along supply chains. These trends highlight the need to identify whether supply chain digitalization can serve as an effective channel for reversing productivity slowdown.

3.3. Coordinated Development of Digitalization and TFP

The relationship between supply chain digitalization and TFP in Guangdong export manufacturing is characterized by positive but incomplete coordination. Leading firms that have built integrated digital supply chains tend to achieve stronger productivity gains through lower transaction costs, faster order response, and improved innovation output. In industrial clusters such as the Pearl River Delta electronics corridor, digital collaboration among core enterprises and supporting

suppliers amplifies productivity improvements within the cluster.

Yet coordination remains limited for most firms. Many SMEs digitize only isolated business functions—such as online receipt of export orders or warehouse record keeping—without connecting digital systems to procurement, production scheduling, or cross-border logistics. As a result, the transmission mechanism from digitalization to TFP is interrupted. Cross-border data barriers, inconsistent standards between domestic and overseas partners, and shortages of composite talent further weaken the linkage between digital investment and productivity outcomes.

Overall, digitalization and TFP in Guangdong export manufacturing are moving in the same direction but at different speeds across regions, industries, and firm sizes. This structural mismatch provides the practical background for examining not only whether digitalization improves TFP, but also through which mechanisms and for which types of firms.

3.4. Structural Problems and Constraints

Despite notable progress, three structural problems continue to constrain the productivity effects of supply chain digitalization in Guangdong export manufacturing.

First, regional and industrial digitalization remains unbalanced. According to industry reports, supply chain management system adoption exceeds 60% among scaled enterprises in eastern coastal regions but remains near 42% in central and western provinces. Within Guangdong, the Pearl River Delta significantly outperforms non-Pearl River Delta areas. Upstream SME suppliers are particularly lagging: while downstream terminal manufacturers often exceed 75% digital penetration, upstream component suppliers remain below 45%, creating a "smart downstream, traditional upstream" pattern that weakens whole-chain efficiency.

Second, TFP growth momentum is insufficient and innovation transmission is weak. Only 29.7% of firms use supply chain data for collaborative R&D, while most digitalization efforts focus on basic operations such as inventory statistics and online order management. Innovation is often limited to incremental process improvement rather than breakthrough technology development. Information asymmetry along supply chains leads to high inventory levels, redundant capacity, and the misallocation of capital and labor toward low-efficiency activities. Many firms also exhibit a "Solow paradox": digital hardware and software are purchased, but internal processes and organizational structures are not redesigned, so digital spending fails to translate into productivity gains.

Third, digital transformation remains at a low-to-medium level. Only 16.4% of firms have entered advanced stages involving joint upstream-downstream R&D, intelligent scheduling, and supply chain risk warning; 56.5% remain at basic informatization, and 27.1% still rely on traditional offline supply chain coordination.

Data silos are widespread: 75.6% of manufacturing firms report cross-partner data barriers, preventing effective data integration and value creation. Meanwhile, the shortage of talent combining supply chain management with digital skills exceeds 3 million nationwide, making it difficult for SMEs to develop customized digital solutions.

These problems are interrelated: uneven digitalization constrains efficiency gains, weak innovation transmission limits TFP improvement, and low-end digital applications fail to unlock data-driven productivity growth. Together, they indicate that supply chain digitalization does not automatically raise TFP; rather, its effects depend on innovation capacity, operational integration, and transaction cost reduction. This provides the practical foundation for the empirical analysis in the following section.

4. Empirical Analysis of Supply Chain Digitalization Effects

This section empirically tests the effect of supply chain digitalization on firm TFP and its mediating mechanisms. The regression sample is drawn from 308 Guangdong manufacturing export firms over 2012–2024, yielding 2,213 firm-year observations after preprocessing, of which 639 observations correspond to the post-policy treatment state (treat_time = 1). All regressions control for firm and year fixed effects, with standard errors clustered at the firm level.

4.1. Descriptive Statistics

Table 3 reports descriptive statistics for the main variables. The regression sample contains 2,213 firm-year observations, including 639 observations with treat_time = 1. The LP-based TFP measure has a mean of 9.0966 and a standard deviation of 1.2475, ranging from 5.9430 to 14.4566. The mean of treat_time is 0.2887, indicating that about 28.87% of observations fall in the treated post-policy period.

Table 3. Descriptive statistics of main variables.

Variable	N	Mean	Std. Dev.	Min	Max
TFP_LP	2213	9.0966	1.2475	5.9430	14.4566
treat_time	2213	0.2887	0.4533	0.0000	1.0000
Innovation	2213	5.4637	1.2791	2.3814	10.4713
OperationEfficiency	2213	0.6600	0.3144	0.0753	2.0182
TransactionCost	2213	-0.2111	1.4333	-2.4960	6.7567
Size	2213	22.2802	1.1978	19.9257	26.4260
Lev	2213	0.4110	0.1786	0.0505	0.8933
ROA	2213	0.0360	0.0727	-0.3701	0.2442
FIXED	2213	0.1854	0.1135	0.0038	0.5387
Cashflow	2213	0.0546	0.0643	-0.1614	0.2656
FirmAge	2213	3.3962	0.8110	1.9459	5.6109
Top10	2213	0.5367	0.1423	0.2259	0.8750
RD	2192	0.1804	0.6087	0.0075	11.1134

Note: Continuous variables are winsorized at the 1st and 99th percentiles by year; RD has 21 missing values, so

regressions with full controls use 2,192 observations.

4.2. Correlation Analysis

Table 4 reports Pearson correlation coefficients among the main variables. TFP is positively correlated with DID (0.313), innovation (0.614), and operational efficiency (0.555), and negatively correlated with transaction cost (-0.284). These correlation directions are consistent with theoretical expectations. No pairwise correlation approaches unity, indicating that multicollinearity is not severe enough to threaten subsequent panel regressions.

Table 4. Pearson correlation matrix of main variables.

Variable	TFP	DID	Innov.	Oper.	Trans.	Size	Lev	ROA	FIXED	Cashflow
TFP	1.000	0.313	0.614	0.555	-0.284	0.844	0.412	0.286	-0.127	0.209
DID	0.313	1.000	0.079	0.217	-0.344	0.124	0.032	0.084	0.016	0.123
Innov.	0.614	0.079	1.000	0.122	0.110	0.644	0.291	0.078	0.066	0.129
Oper.	0.555	0.217	0.122	1.000	-0.271	0.186	0.331	0.270	-0.034	0.177
Trans.	-0.284	-0.344	0.110	-0.271	1.000	-0.172	0.003	-0.269	-0.107	-0.203
Size	0.844	0.124	0.644	0.186	-0.172	1.000	0.404	0.201	-0.079	0.136
Lev	0.412	0.032	0.291	0.331	0.003	0.404	1.000	-0.257	0.088	-0.141
ROA	0.286	0.084	0.078	0.270	-0.269	0.201	-0.257	1.000	-0.089	0.427
FIXED	-0.127	0.016	0.066	-0.034	-0.107	-0.079	0.088	-0.089	1.000	0.171
Cashflow	0.209	0.123	0.129	0.177	-0.203	0.136	-0.141	0.427	0.171	1.000

Note: Pearson correlation coefficients are reported. DID denotes treat_time.

4.3. Baseline Regression Results

Table 5 reports the benchmark DID regression results. Supply chain digitalization has a significant positive effect on firm TFP. Without control variables, the treat_time coefficient is 0.7063; after firm-level controls are added, the coefficient is 0.7011 and remains significant at the 1% level. The within R^2 increases from 0.1717 to 0.5159 after controls are included. These results support H1 and indicate that the supply chain digitalization pilot policy significantly improves the TFP of Guangdong manufacturing export firms.

Table 5. Benchmark DID regression results.

Variable	(1) Baseline	(2) With Controls
treat_time	0.7063*** (0.1462)	0.7011*** (0.1144)
Size		0.7102*** (0.0629)
Lev		0.2987 (0.2036)
ROA		0.7578*** (0.2434)
FIXED		-0.7604*** (0.2909)
Cashflow		0.7717*** (0.2052)
FirmAge		0.4292 (0.3168)
Top10		0.3233 (0.2681)
RD		-0.0041 (0.0131)
Constant	8.8171*** (0.0676)	-7.8998*** (1.6266)
Observations	2213	2192
Within R^2	0.1717	0.5159

Firm FE / Year FE	Yes / Yes	Yes / Yes

Note: Values in parentheses are firm-clustered robust standard errors; *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

4.4. Parallel Trend and Robustness Tests

To further validate the baseline findings, this section conducts parallel trend and placebo tests, together with additional robustness checks summarized in Table 6. In the parallel trend test, the joint significance test for pre-policy periods yields p = 0.2488, so the null hypothesis of parallel pre-trends cannot be rejected. In the placebo test, the true coefficient is 0.7011, whereas the mean coefficient from 500 random reassignments is -0.0019, with an empirical p-value of 0.0000. PSM-DID, alternative TFP measurement (TFP_OP), and exclusion of the policy year 2018 all yield conclusions consistent with the baseline regression.

Table 6. Summary of robustness tests.

Test	Core Coefficient	Std. Error	Observations	Within R^2	Conclusion
PSM-DID	0.6682***	(0.1227)	1234	0.5825	Robust
Replace dep. var. TFP_OP	0.2500**	(0.1190)	2192	0.4820	Robust
Exclude policy year 2018	0.7128***	(0.1197)	2024	0.5271	Robust
Parallel trend test	p = 0.2488		2192		Pre-policy joint insignificance
Placebo test	Empirical p = 0.0000		500 simulations		True coefficient not from random assignment

5. Discussion of Empirical Findings and Mechanisms

The empirical results in Section 4 are fully consistent with the theoretical framework developed in Section 2 and the status analysis in Section 3. Table 5 confirms that the 2018 supply chain pilot policy significantly raises TFP, and the robustness summary in Table 6 shows that this conclusion is not driven by sample selection, alternative TFP measurement, policy-year interference, or pre-existing trends.

Tables 7 and 8 further clarify how digitalization translates into productivity gains. At the innovation level, the pilot policy expands access to innovation resources and alleviates financing constraints, thereby increasing patent output and TFP. At the operational level, digitalization improves internal coordination and asset turnover, especially for export firms facing cross-border order scheduling constraints. At the transaction-cost level, digital platforms reduce information asymmetry between firms and overseas customers or suppliers, lowering search, negotiation, and monitoring costs along export supply chains.

Heterogeneity analysis (reported in the mid-term empirical work) further indicates that the productivity effect is stronger among firms with larger export volumes, those located in the Pearl River Delta, high-tech manufacturing firms, and state-owned enterprises with greater policy responsiveness. These patterns suggest

that digitalization dividends are unevenly distributed and require differentiated policy support across regions, industries, and ownership types.

6. Policy Recommendations and Practical Implications

Based on the empirical findings, this paper recommends cooperating with enterprises and local governments to build targeted policy measures according to a unified implementation template (see Table 9).

Table 7. Policy recommendation template for supply chain digitalization (examples).

Policy Area	Target Group	Core Measures
Enterprise Digital Upgrade	Export manufacturing SMEs	End-to-end digital integration across procurement, production, logistics
Regional Coordination	Non-Pearl River Delta firms	Shared digital platforms and infrastructure subsidies
Innovation Incentives	High-tech manufacturers	R&D tax credits linked to supply chain data utilization

At the enterprise level, export manufacturers should prioritize end-to-end digital integration and leverage supply chain data for collaborative innovation. At the government level, policies should address regional digital gaps and provide targeted support for SMEs. At the ecosystem level, industry clusters should build shared digital platforms to reduce data silos and cultivate composite talent combining supply chain expertise with digital skills.

7. Implementation Pathway and Quality Evaluation

To ensure implementation of the policy recommendations, a three-phase approach is recommended: Phase 1 (1 year)—complete pilot digitalization programs for large export firms and establish baseline TFP monitoring; Phase 2 (1–2 years)—extend shared digital platforms to SMEs and non-Pearl River Delta regions; Phase 3 (ongoing)—carry out university-enterprise joint research and iterative policy optimization.

Quality evaluation should adopt multiple indicators: at the firm level, monitor TFP growth and digital investment ratios; at the regional level, track platform adoption rates and cross-regional collaboration indices; at the policy level, assess patent output, export performance, and employment matching rates.

8. Conclusion

Based on panel data from 308 Guangdong manufacturing export firms and a DID framework leveraging the 2018 supply chain pilot policy, this paper finds that supply chain digitalization significantly enhances firm TFP. The baseline treat_time coefficient is 0.7011 (significant at the 1% level), as reported in Table 5. The robustness summary in Table 6 confirms that the result is stable under PSM-DID, alternative TFP measurement, sample adjustment, parallel trend testing, and placebo testing. Mediation analysis in Tables 7 and 8 shows that innovation capability, operational efficiency, and transaction cost reduction are all significant

partial mediating channels through which supply chain digitalization improves firm TFP.

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References

[1] Benfratello, L., Schiantarelli, F. and Sembenelli, A. (2008) Banks and Innovation: Microeconometric Evidence on Italian Firms. Journal of Financial Economics, 90, 197-217.

[2] Calatayud, A., Mangan, J. and Christopher, M. (2019) The Self-Thinking Supply Chain. Supply Chain Management: An International Journal, 24, 22-38.

[3] Gong, G. and Hu, G. (2013) Resource Allocation Efficiency and Total Factor Productivity in Chinese Manufacturing. Economic Research Journal, 48, 4-15.

[4] Guo, Y. (2018) Signal Transmission Mechanism of Government Innovation Subsidies and Enterprise Innovation. China Industrial Economics, 9, 98-116.

[5] Levinsohn, J. and Petrin, A. (2003) Estimating Production Functions Using Inputs to Control for Unobservables. Review of Economic Studies, 70, 317-341.

[6] Li, C. and Wang, M. (2024) Can Supply Chain Digitalization Improve Enterprise TFP? Research on Financial and Economic Issues, 5, 75-88.

[7] Liu, H., Hu, H. and Zhang, S. (2023) Green Innovation Effects of Supply Chain Digitalization. Journal of Finance and Economics, 49, 4-18.

[8] Lu, X. and Lian, Y. (2012) Estimation of TFP in Chinese Industrial Firms: 1999-2007. China Economic Quarterly, 11, 541-558.

[9] Tao, F., Wang, X. and Xu, Y. (2023) Digital Transformation, Supply Chain Resilience and Firm Productivity. China Industrial Economics, 5, 118-136.

[10] Wen, Z. and Ye, B. (2014) Analyses of Mediation Effects: The Development of Methods and Models. Advances in Psychological Science, 22, 731-745.

[11] Zhang, Q. and Duan, Y. (2023) Digital Empowerment, Industrial Chain Integration and TFP. Business Management Journal, 45, 5-21.

[12] Zhang, S., Hu, H. and Sun, L. (2021) Supply Chain Digitalization and Supply Chain Security: A Quasi-Natural Experiment. China Soft Science, 12, 21-30.