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Abstract

Industrial subsidies are at the center of the recent political and economic debate. This paper examines the impacts of subsidies along domestic value chains on the export performance of Chinese firms. Using firm-level subsidy data and inter-provincial input-output tables, we measure direct subsidies and indirect subsidies in upstream industries. Our findings reveal several vital points: (1) Direct subsidies significantly enhance Chinese firms' export participation and volume. These subsidies are positively associated with firm investment and R&D expenditure. (2) Surprisingly, upstream indirect subsidies—particularly those from 1st tier upstream industries—have even larger effects on Chinese exports than direct subsidies. These upstream subsidies contribute significantly to export growth. (3) Both domestic firms and foreign-invested enterprises benefit from direct subsidies, but the effect of upstream subsidies varies by ownership. (4) Both direct and indirect subsidies are associated with higher export prices and product quality, leading to a lower quality-adjusted price. These export growth and quality upgrading are driven by direct subsidies through increased investment and R&D, and indirect subsidies through intermediate inputs. These results suggest that government support may promote quality upgrading and enhance the global competitiveness of Chinese exports. This paper contributes to the ongoing debate on government subsidy and industrial policy by shedding light on the intricate relationship between subsidies and exports.

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Subsidies along Value Chains and their Impacts on China's Exports[1]

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Abstract

Industrial subsidies are at the center of the recent political and economic debate. This paper examines the impacts of subsidies along domestic value chains on the export performance of Chinese firms. Using firm-level subsidy data and inter-provincial input-output tables, we measure *direct* subsidies and *indirect* subsidies in upstream industries. Our findings reveal several vital points: (1) Direct subsidies significantly enhance Chinese firms' export participation and volume. These subsidies are positively associated with firm investment and R&D expenditure. (2) Surprisingly, upstream indirect subsidies—particularly those from 1st tier upstream industries—have even larger effects on Chinese exports than direct subsidies. These upstream subsidies contribute significantly to export growth. (3) Both domestic firms and foreign-invested enterprises benefit from direct subsidies, but the effect of upstream subsidies varies by ownership. (4) Both direct and indirect subsidies are associated with higher export prices and product quality, leading to a lower quality-adjusted price. These export growth and quality upgrading are driven by direct subsidies through increased investment and R&D, and indirect subsidies through intermediate inputs. These results suggest that government support may promote quality upgrading and enhance the global competitiveness of Chinese exports. This paper contributes to the ongoing debate on government subsidy and industrial policy by shedding light on the intricate relationship between subsidies and exports.

Keywords: Industrial subsidies, Export, Upstream, Value chains

JEL classification: F10, F14

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1. Introduction

"China continues to provide massive subsidies to its domestic industries, which have caused injury to U.S. industries and the industries of other WTO Members. Some of these subsidies also appear to be prohibited under WTO rules."

— United States Trade Representative 2023 Report to Congress on China's WTO Compliance, February 2024.[6]

"China's subsidy policies are strictly under WTO rules and have not caused market distortion or unfair competition."

—Vice-Minister of Finance Zou Jiayi, September 25, 2018.[7]

In recent years, industrial subsidies have witnessed significant growth in China and other major economies, including the U.S., EU, and Japan. According to the Global Trade Atlas (GTA) database, the number of subsidies implemented each year worldwide has more than tripled in the last decade.[8] It is called subsidy competition or subsidy war. The increasing use of subsidies by governments worldwide raises concerns about their effects on international trade.[9] The World Trade Organization (WTO) has highlighted subsidies' opacity and potential impact on market distortions and overcapacity.[10]

Industrial subsidies in China have risen dramatically, as shown in Figure 1. The amount of subsidies to industrial sectors was 27 billion RMB in 1998, which increased to 145 billion in 2013. It is estimated to reach 433 billion RMB in 2022. Local or central government subsidies surged in 2008 as industrial production substantially declined and trade collapsed due to the global financial crisis.[11] A recent dataset from Chinese listed firms reveals an acceleration of subsidies after the "Made in China 2025" Program in 2015 and the U.S.-China trade war in 2018. On the other hand, China experienced a miracle growth in international trade. In 1998, China accounted for only 3.5 percent of the world's total exports; China's share rose to 11 percent in 2013 and

[6] https://ustr.gov/about-us/policy-offices/press-office/press-releases/2024/february/ustr-releases-annual-report-chinas-wto-compliance

[7] https://english.www.gov.cn/news/video/2018/09/25/content_281476317804792.htm

[8] https://www.globaltradealert.org/

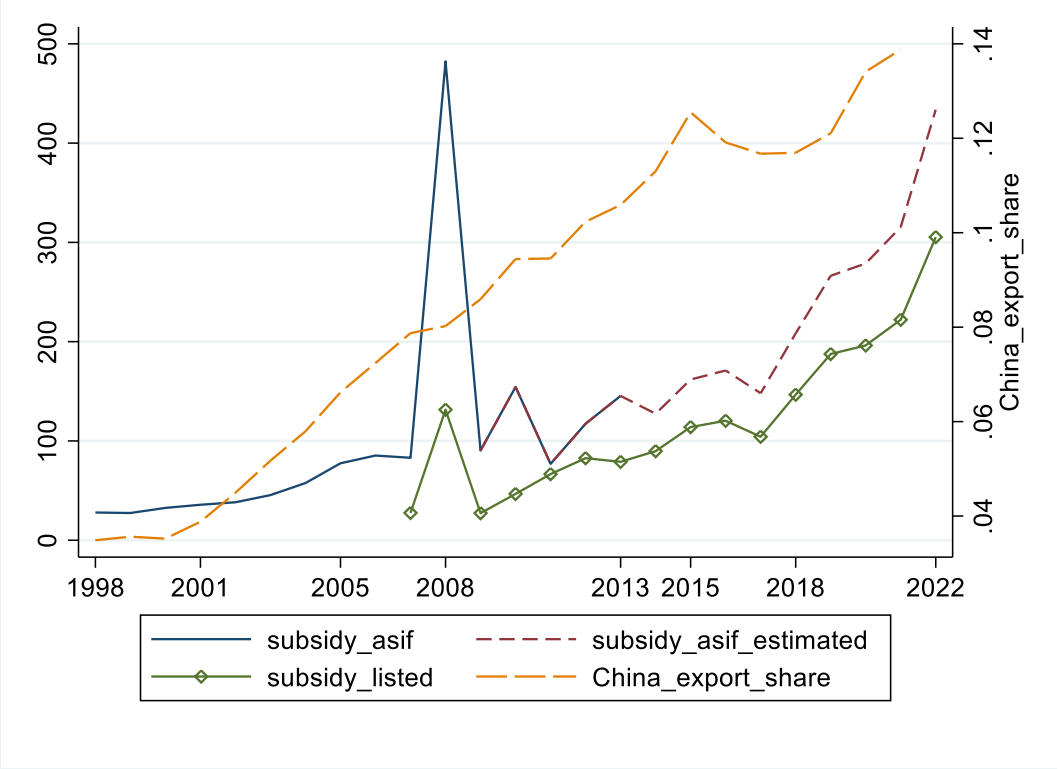
[9] More generally, there is hot debate on the effectiveness of industrial policy among policymakers and economists (e.g., Irwin, 2023; Juhasz, Lane, and Rodrik 2023).

[10] There are several reasons for governments to subsidize firms: industrial development, export promotion, supporting firms to innovate, and securing a national advantage in leading industries (WTO, 2006).

[11] In 2009, to minimize the impact of the global financial crisis on the Chinese economy, the Chinese government implemented an economic stimulus program investing 4 trillion RMB in infrastructure and social welfare.

further rose to 14% in 2021. China's emergence as the largest exporting country has fueled much debate on its industrial and trade policy. Rodrik (2006) suggests that industrial policies have played an essential role in shaping China's industrial structure and export activity. Girma, Gong, Gorg, and Yu (2008) document that production-related subsidies played an important role in increasing China's export volumes from 1999 to 2005.

Figure 1. The rise of industrial subsidies in China



Notes: Subsidies are in billion RMB. Subsidies are direct government payments to manufacturing, mining, and electricity/water/gas industries. Source: Authors' compilation based on the Annual Survey of Industrial Firms (ASIF), WIND listed firms database, and World Integrated Trade Solution (WITS).

In this paper, we study the impacts of industrial subsidies along the domestic value chains on firm- and firm-product-destination-level exports. Using a unique dataset on firm-level subsidy and inter-provincial input-output tables, we measure direct subsidies in subsidized industries and indirect subsidies from upstream sectors. Much attention has been paid to direct subsidies in the literature, but there is scarce evidence on the indirect effects of upstream government support on downstream firms. This is the first study to quantitatively assess the impact of direct and indirect subsidies through input-output linkage on export activity, using comprehensive firm-level trade data.

Our empirical analysis utilizes an unbalanced panel dataset comprising more than 3 million firm-year observations from 1998–2013, including the rare information on industrial subsidies received by Chinese firms from either local or central government.[12] We document strong evidence that industrial subsidies substantially impact the export performance of Chinese firms. First, direct subsidies stimulate export activity at extensive and intensive margins, although this effect on extensive margin is relatively small. Second, indirect subsidies—particularly those from 1st tier upstream industries—have even larger effects on trade margins than direct subsidies. Third, domestic and foreign-invested firms benefit from direct subsidies, but the impact of upstream subsidies varies by ownership, highlighting the nuanced relationship between subsidies and export performance. (4) Both direct and indirect subsidies are associated with higher export prices and product quality, leading to a lower quality-adjusted price. These export growth and quality upgrading are driven by direct subsidies through firm-level investment and R&D expenditure and indirect subsidies through intermediate inputs from upstream industries.

In summary, subsidized firms can export larger volumes and charge higher prices due to improved product quality. This dual impact—quantity (volume) and quality—makes subsidies a powerful tool for enhancing China's export competitiveness. By systematically investigating the effects of subsidies along value chains on trade, we provide evidence-based insights for policymakers, industry stakeholders, and researchers. Understanding the impact of subsidies on international competitiveness is crucial for informed decision-making and sustainable economic growth.

The remainder of this paper is organized as follows. Section 2 presents related literature. Section 3 describes the data and variables and reports descriptive statistics. Section 4 presents estimation equations and Section 5 reports the empirical results and discussion. Finally, section 6 concludes the study.

2. Related literature

Our study is closely related to the literature on subsidies and trade. Using firm-level data, Girma, Gong, Gorg, and Yu (2008) find that China's production subsidies stimulate export activity at the intensive margin, although this effect is conditional on firm characteristics. Their analysis focuses on domestic-owned firms only. By contrast, Bernard and Jensen (2004) find no significant impact of export promotion expenditures at the state level on the exporting decision of U.S. plants. More recently, using detailed data on domestic subsidies across many advanced and emerging

[12] It is important to point out that we are not considering export-specific subsidies but general production-related subsidies. This is also pointed out by Girma, Gong, Gorg, and Yu (2008).

economies, Rotunno and Ruta (2024) find that on average, subsidies promote both exports and imports. These effects are partly driven by selection into subsidies, as governments target export-oriented and import-competing products. These studies examine the relationship between direct subsidy and export performance without considering the possible indirect effects of subsidies in the upstream industries. This paper contributes to the international trade and industrial policy literature by providing novel evidence of the impacts of industrial subsidies on exports, both directly and indirectly, through input-output linkages.

In evaluating the indirect effects of subsidies, this paper relates to recent literature on production networks and supply chains. From the perspective of production networks, policies subsidizing upstream industries may correct distortions such as market imperfections (e.g., financial constraints), the rise in input prices and production costs, and resource misallocation, thereby enhancing overall economic efficiency. Liu (2019) estimates that subsidies to state-owned and non-state-owned enterprises in upstream industries increase the efficiency of the Chinese economy by about 4.8 percent. Blonigen (2016) empirically studies the trade effects of specific industrial policies (including export and production subsidies, government ownership, cartel arrangements, and non-tariff measures) targeting the steel industry on downstream export performance. Using industry-level information on federal subsidies in the U.S., Navarra (2023) finds that subsidies boost the exports of subsidized and indirectly subsidized downstream industries through input-output linkages. Our contribution to the literature is that we use detailed firm-level data on subsidies and disaggregated inter-provincial input-output tables to construct subsidies in the 1st tier and all 2nd tier upstream industries. We examine the direct and indirect impacts of subsidies on various indicators of export performance (trade margins, export price, and product quality) at both firm and firm-product-destination levels.

Several studies have explored the impacts of subsidies and industrial policy on firm productivity and international competitiveness. Aghion, Cai, Dewatripont, Du, Harrison, and Legros (2015) show that industrial policies such as policy loans, subsidies, and tariff reductions implemented in competitive industries and those that stimulate competition within an industry have improved the productivity of manufacturing firms. Kalouptsidi (2018) and Barwick, Kalouptsidi, and Zahur (2019) revealed that industrial policies in the Chinese shipbuilding industry in the 2000s significantly reduced costs for shipyards, promoted domestic investment and entry, and dramatically expanded their market share in the international market (leading to a decrease in market share for Japan and Korea). By contrast, Blonigen (2016) estimates that a one standard deviation increase in industrial policy interventions in the U.S. steel industry is associated with a 3.6 percent decline in export competitiveness for downstream manufacturing industries. This

paper provides novel evidence of positive trade effects (export margins and, more importantly, quality upgrading) of industrial subsidies along domestic value chains.

Finally, our paper also relates to a broad literature on subsidies and industrial policy. Juhász, Lane, and Rodrik (2023) review the literature. Many studies have investigated the effects of R&D subsidies (e.g., Hall and Van Reenen 2000, Bloom, Griffith, and Van Reenen 2002, and Bronzini and Iachini 2004), industrial location subsidies (e.g., Neumark and Simpson 2015, Criscuolo, Martin, Overman, and Van Reenen 2019), export subsidies (e.g., Bernard and Jensen 2004), and industrial and production subsidies (e.g., Girma, Gong, Gorg, and Yu 2008, Zhang 2021). To our knowledge, this study is the first to quantitatively assess the impacts of industrial subsidies along domestic value chains on international trade at the firm and firm-product-destination levels.

3. Data

3.1 The Annual Survey of Industrial Firms

Our primary data set comes from the Annual Survey of Industrial Firms (ASIF) conducted by China's National Bureau of Statistics (NBS) from 1998–2013. The survey covers all industrial firms that are state-owned enterprises (SOEs), and non-SOEs with sales above RMB 5 million.[13] The industry is defined here to include mining, manufacturing, and electricity/heat/water. We focus on manufacturing firms to analyze export performance, but we also use information on mining and electricity/heat/water firms to construct indirect upstream subsidies. This study requires precise information on the industry and location of the sample firms. Each firm is classified into one sector following the 4-digit Chinese Industry Classification.[14] The data set provides information on each firm's address and regional codes.[15]

This data set contains firm-level information on sales, export value, subsidy, the book value and net value of fixed assets, the number of employees, and wage bills, which are essential to this study. We depreciate firm sales, exports, subsidies, and wage bills by two-digit industry-level output deflators from the China Statistical Yearbook compiled by the NBS. One drawback of this data set is that it does not directly provide information on capital investment. Following Liu and

[13] The threshold of sales incrased to 20 million after 2011.

[14] However, in 2003, a new classification system for industry codes (GB/T 4754-2002) was adopted to replace the old classification system (GB/T 4754-1994). To make the industry codes comparable across the entire period, following Brandt, Van Biesebroeck, and Zhang (2012), we use a harmonized classification that grouped some industries before and after the revision.

[15] During the sample period, however, the administrative boundaries and city codes experienced some changes. Using the 1999 National Standard (GB/T2260-1999) as the benchmark codes, we convert the city codes of all the firms into these benchmark codes to achieve consistency for the city codes in the whole sample period.

Lu (2015), we use book values of fixed assets and assume a constant depreciation rate of 5 percent. During this process, we realize the investment and capital stock using the provincial fixed investment price index from the China Statistical Yearbook. Following Brandt, Van Biesebroeck, and Zhang (2012), we drop firms that have missing, zero, or negative values for sales, fixed assets, and wage bills since the logarithms of these variables are not defined. We further drop firms with less than eight employees as they fell under a different legal regime. The data contains ownership information: SOEs, private firms, and foreign-invested enterprises (FIEs).[16] In practice, we use the firm's registered type information to classify ownership into three groups: private domestic firms, SOEs, and FIEs.

ASIF contains unique information on subsidies, which is crucial for this study. According to NBS, subsidy refers to the government's regular payment of a fixed subsidy amount based on production volume, sales, etc., or the amount returned from collected value-added taxes. Subsidies can come from both local and central governments.[17] There is no information on direct export subsidies; these payments are considered production-related subsidies (Girma, Gong, Gorg, and Yu, 2008). However, it is unclear what exact purpose the payments were provided for or how firms used these subsidies. It is worth mentioning that the subsidy information is not available in 2009, 2010, and 2012. In our analysis, we interpolate them by averaging subsidy amounts in 2007, 2011, and 2013.[18]

Given that our primary interest is in the impact of subsidies on exports, we present the number of exporters and the number of subsidized firms during our sample period in Table 1. The numbers of exporters, subsidized firms, and subsidized exporters increased significantly from 1998 to 2013 partly because the survey sample size increased during this period. The shares of exporters and subsidized firms in the total manufacturing firms are relatively steady, approximately 20 percent and 10 percent each year. Interestingly, the share of subsidized exporters increased from 10 percent in 1998 to 20 percent in 2013 (column 5). The year 2008 is an exception due to the global financial crisis. Table A1 in the Appendix reports the summary statistics of ASIF used in our analysis. The mean subsidy amount is 322 thousand RMB, and significant variations exist across firms. Exporters and FIEs

[16] According to the Criteria for Classifications of the Registration of Enterprise Ownership Types issued by the NBS, only enterprises whose foreign capital accounts for no less than 25% of the total registered capital were eligible to be registered as foreign-invested enterprises.
[17] Other than these direct payments from government, export rebate is a fiscal device for encouraging export. Since 2000, the government pays more than 100 billion RMB each year for export tax rebate. However, export rebate is not included in the definition of subsidy in Chinese government expenditure (Girma, Gong, Gorg, and Yu, 2008).
[18] We do not use 2008 data for interpolation as subidies surged during the 2008 global financial crisis shown in Figure 1.

account for 25.4 percent and 20.2 percent of total observations, respectively.

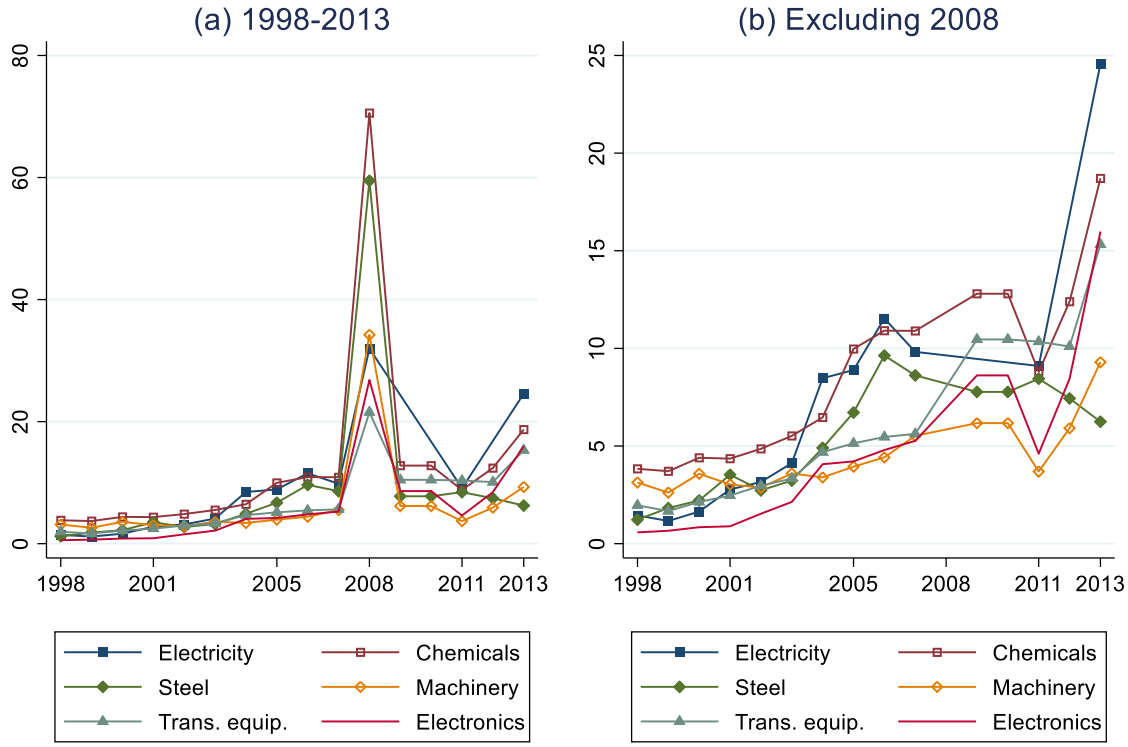
Table 1. Number of exporters and subsidized firms

	(1)	(2)	(3)	(4)	(5)
year	# of firms	# of exporters	# of subsidy firms	# of subsidy exporters	=(4)/(2)
1998	140,849	34,797	13,542	3,490	0.10
1999	137,566	34,062	14,272	4,099	0.12
2000	139,074	36,556	15,144	4,911	0.13
2001	148,725	40,124	16,624	6,106	0.15
2002	159,544	44,641	19,832	7,748	0.17
2003	176,131	50,267	23,603	9,794	0.19
2004	247,411	75,198	36,404	15,852	0.21
2005	244,462	73,581	32,878	12,976	0.18
2006	274,339	77,779	35,741	13,965	0.18
2007	308,811	78,413	38,206	14,200	0.18
2008	380,718	87,562	175,363	56,070	0.64
2009	397,863	82,714	62,945	24,535	0.30
2010	315,508	92,017	62,726	24,391	0.27
2011	256,555	59,644	22,362	9,759	0.16
2012	275,857	62,689	36,234	16,064	0.26
2013	285,767	58,516	30,022	12,352	0.21
Total	3,889,180	988,560	635,898	236,312	0.24

Source: Authors' compilation based on the ASIF.

Figure 2 shows the trend of subsidies in major industries. In absolute values, subsidies were highest in the electricity (25 billion RMB) and chemicals (18 billion RMB) industries in 2013. These industries are upstream industries and supply inputs to downstream sectors. The steel industry received a large amount of subsidies before 2008 but gradually declined after 2008, suggesting a possible reduction of overcapacity in this industry. By contrast, subsidies for transportation equipment and electronics increased significantly after 2008, reaching 15 billion RMB in 2013. This perhaps reflects some shift of resources towards high-tech industries.

Figure 2. Industrial subsidies in major industries



Note: Billion RMB. Subsidies in 2009, 2010, 2012 are adjusted value. Source: ASIF, NBS.

Notes: Industry classification is based on 2002 China Input-Output Tables. Source: Authors' compilation based on the ASIF.

To better understand which types of firms are likely to be subsidy recipients, Table 2 presents the results of an exploratory econometric analysis where we regress the subsidized firm dummy on a number of firm characteristics that we expect to be correlated with subsidy receipt. We find that all other things equal, (1) relative to non-exporters, exporters have approximately a 5 percent higher probability of receiving subsidies from the government. This is true for both domestic firms and foreign firms. (2) larger firms, high-profitability firms, and old firms are more likely to be subsidy recipients.[19] (3) not surprisingly, SOEs are more likely to be subsidized than private or foreign firms.

[19] China entered the WTO in December 2001 and signed the Agreement on Subsidies and Countervailing Measure (SCM), in which the Chinese government agreed to reduce subsidies substantially to the SOE sectors, in particular, subsidies for loss-making SOEs.

Table 2. Determinants of subsidy receipt

	(1)	(2)	(3)
	Full	Domestic	Foreign
exporter	0.0585***	0.0633***	0.0558***
	(0.000936)	(0.00117)	(0.00151)
lagged sales	0.0278***	0.0299***	0.0252***
	(0.000376)	(0.000419)	(0.000813)
lagged profitability	0.0352***	0.00830**	0.0986***
	(0.00329)	(0.00400)	(0.00557)
lagged wage	0.0380***	0.0373***	0.0370***
	(0.000374)	(0.000416)	(0.000818)
age	0.0181***	0.0187***	0.00499***
	(0.000536)	(0.000578)	(0.00139)
SOE	0.0705***	0.0564***	
	(0.00184)	(0.00188)	
FIE	0.00660***		
	(0.00103)		
Province FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
N	2771087	2174694	596393
adj. R-sq	0.169	0.154	0.232

Notes: Dependent variable: subsidized firm dummy. ASIF 1998-2013 sample. Standard errors are clustered at the firm level. Significance levels: * 0.10 ** 0.05 *** 0.01

3.2 Chinese Customs data

The second data source is the census of annual export and import transactions of Chinese firms covering 2000–12, collected by China's General Administration of Customs. The database records a firm's trade value, import source, export destination, and trade mode (processing versus ordinary trade) at the HS 8-digit product level.[20] The Chinese customs data has been widely used in previous studies on Chinese firms' trade activities and performance. These data report the free-on-board value for both exports and imports in US dollars. They also record the quantities traded in one of 12 different units of measurement, such as kilograms and square meters, which makes it possible to construct unit values. Some firms are pure trading companies that do not engage in manufacturing. We have aggregated the data to the HS 6-digit level to concord it consistently over time using the conversion table from the UN Comtrade.

[20] Following standard practice in the literature, we identify such intermediaries and wholesalers using keywords in firms' names and exclude them from our sample.

It is worth noting the structure of our data for analysis. We need to square the dataset to capture export participation and track a given firm-product-destination combination over 2000–2012. We can assign a zero trade value if a firm does not export to a given product-destination. To limit the sample size within manageable technical capacity, we drop small trade partners whose trade value falls in the bottom ten percentile of total Chinese exports. We further exclude occasional exporters to avoid the problem caused by export churning. Specifically, we include firm–HS6-destination observations in our regressions with positive exports at least thrice during 2000–12.

Our analysis based on the Customs data is at the firm-product-destination-year level. We consider various outcomes of firms' export behavior and performance.

(i) Entry (extensive margin) is a dummy variable, which equals one if there is no export in year t-1 but export in year t.

(ii) Export value (intensive margin) is computed as the log of export value of incumbent exporters.

(iii) Export quantity (intensive margin) is computed as the log of export quantity of incumbent exporters.

(iv) Export price is the log of unit value computed as export value over quantity.

(v) Product quality is estimated at the firm-product level following Khandelwal (2010) and Amiti and Khandewal (2013) described below.[21]

(vi) Quality-adjusted export price is defined below.

We estimate the effective quality—as it enters consumer's utility—of product p exported to destination d by firm i in year t, using the following demand equation:

$$\ln\left(Quantity_{ipdt}\right) + \sigma \ln\left(Price_{ipdt}\right) = FE_p + FE_{dt} + \epsilon_{ipdt} \quad (1)$$

Then, the estimated quality is $\ln\left(\widehat{Quality}_{ipdt}\right) = \hat{\epsilon}_{ipdt}$. Conditional on price, a variety with a larger quantity (demand) is assigned higher quality. Keith and Ries (2001) showed that the value

[21] Product quality is not observed directly. Unit values, defined as the ratio of trade value over quantity for each product, are observable and often used in earlier studies as a proxy (Schott, 2004; Hummels and Klenow, 2005). Notwithstanding its simplicity, unit value may be driven by factors other than quality. For example, higher prices do not necessarily reflect better quality but result from higher production costs. To overcome this issue, Khandewal (2010) proposed a novel approach to estimate quality using both unit value and export quantity. Quality is defined as the unobserved attributes of a variety that make consumers willing to purchase relatively large quantities of it despite relatively high prices.

of the elasticity of substitution σ is between 5 and 10. We set it at the commonly used value $\sigma = 5$ (e.g., Manova and Yu, 2017), but our results are robust to alternative choices over σ. To further examine the net welfare impact of subsidies on foreign consumers, we calculate quality-adjusted export price, which is measured as the difference between export prices and product quality.

Finally, following Yu (2015), we use the firm name, telephone number, postal code, and address to match the Customs data with the ASIF data. Table A2 in the Appendix presents summary statistics of our variables. The mean subsidy amount is 2,192 thousand RMB, much larger than that in ASIF as the matched sample contains exporting firms only.

3.3 Inter-provincial Input-Output Table

The input-output tables utilized in this paper have been developed by Chen, Gao, Pan, et al. (2023). This dataset is noteworthy as it provides ownership-related data for China's inter-provincial IO tables, encompassing 42 sectors and 31 provinces across five benchmark years (1997, 2002, 2007, 2012, 2017). The ownership categories include mainland China-owned, Hong Kong-owned, Macau-owned, Taiwan-owned, and foreign-owned firms. With this vital information at our disposal, we can examine the impacts of subsidies in upstream sectors, considering the various ownership structures on the exports of the focal industry with distinct ownership characteristics.

Using inter-provincial input-output tables and firm-level subsidy data, we construct subsidies (intensities) in 1st-tier and 2nd-tier upstream industries as follows:

$$Up^1_{jor,t} = \sum_{ips} \frac{M^1_{jor,t}}{X_{jor,t}} \frac{M^1_{ips,jor,t}}{\sum_{ips} M^1_{ips,jor,t}} \cdot \frac{S_{ips,t}}{V_{ips,t}} = \sum_{ips} \frac{M^1_{ips,jor,t}}{X_{jor,t}} \cdot \frac{S_{ips,t}}{V_{ips,t}} \quad (2)$$

$$Up^2_{jor,t} = Up_{jor,t} - Up^1_{jor,t} = \sum_{ips} \left(\frac{M_{ips,jor,t}}{X_{jor,t}} - \frac{M^1_{ips,jor,t}}{X_{jor,t}} \right) \cdot \frac{S_{ips,t}}{V_{ips,t}} \quad (3)$$

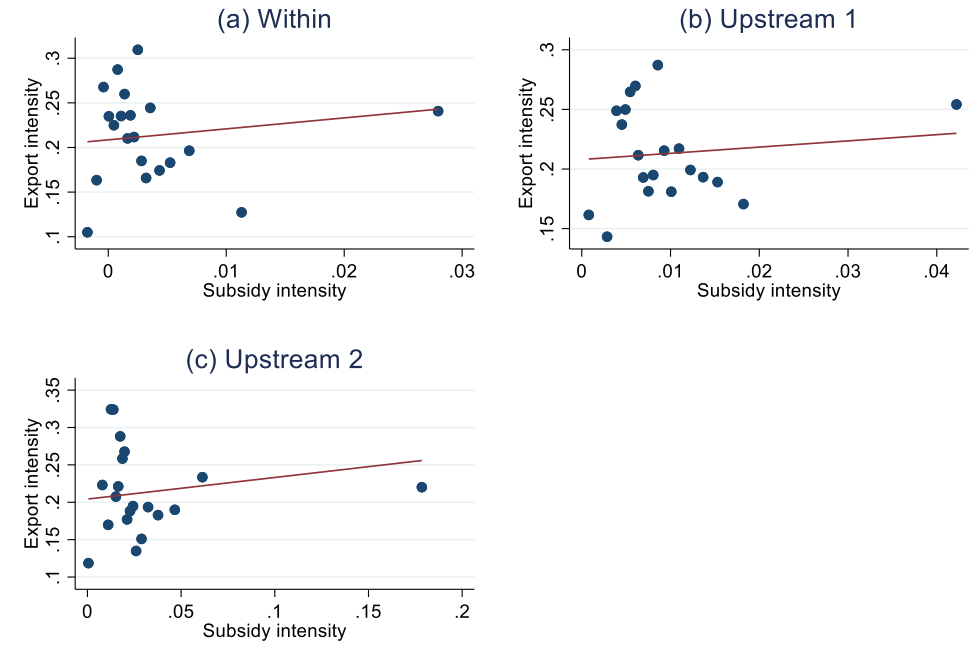
We index the sector by i and j, ownership by o and p, and province by r and s. Additionally, we employ the symbols j, o and r to denote the sector-ownership-province of the target sector, while i, p, and s are utilized to represent the upstream sector. t indicates the year. We use V and X to signify the nominal value added and output, respectively. M refers to the inflow of intermediate goods from other provinces. Furthermore, S represents the subsidy amount, and $\frac{S}{V}$ indicates subsidy intensity.

Sector i can directly supply intermediate goods to sector j, thereby acting as its direct 1st-tier upstream sector. In addition, sector i can provide intermediate goods to the suppliers of sector j, thus serving as an indirect 2nd-tier upstream sector for sector j. Leontief inverse matrix of the input-output table encapsulates both 1st-tier and 2nd-tier upstream effects. The direct input coefficient $\frac{M_{ips,jor,t}}{X_{jor,t}}$ quantifying the immediate 1st-tier upstream effect ($Up^1_{jor,t}$) by serving as the weighting for subsidy intensity. The gap between the Leontief input coefficient and the direct input coefficient can be used to capture the indirect 2nd-tier effect of subsidies ($Up^2_{jor,t}$), namely the effect from all indirect upstream sectors.

Table A3 in the Appendix reports the summary statistics of upstream subsidies. The mean subsidy intensity in 1st-tier and 2nd-tier upstream industries are 1.3 percent and 4.2 percent, respectively. These numbers are reasonable as the 2-tier upstream includes all upstream except the direct upstream of the focal industry. Similarly, by ownership, the subsidy in the 2nd-tier upstream is larger than in the 1st-tier upstream. Our measure of province-sector-ownership-level upstream subsidies can be aggregated to different levels, such as province-sector-level.

Figure 3 shows the binned scatterplots of the relationship between subsidy and export intensity using the ASIF 2007 data. There is a positive correlation between direct subsidy and export (panel a), indirect 1st-tier upstream subsidy and downstream export (panel b), and indirect 2nd-tier upstream subsidy and downstream export (panel c).

Figure 3. Subsidies and exports: industry-province-level



ASIF production data in 2007.

Notes: Each dot indicates a bin of province-sector observation. Source: Authors' compilation based on the ASIF and inter-provincial IO table.

4. Specification

The firm-level regression analysis can be carried out based on equation (4).

$$y_{jor,t} = \alpha + \beta_1 S_{fjor,t} + \beta_2 SUp^1_{jor,t} + \beta_3 SUp^2_{jor,t} + \sum \gamma X_{fjor,t} + FE_f + FE_t + \varepsilon_{jor,t} \quad (4)$$

The dependent variable $y_{fjor,t}$ is the export participation dummy (extensive margin) and log export value (intensive margin) of firm f sector j ownership o in province r for the year t. β_1 quantifies the direct effects of subsidies within the focal firm, β_2 captures the effects of subsidies in the 1st tier upstream industries and β_3 measures the effects of subsidies in all 2-tier upstream industries. The control variables, which could potentially influence export outcomes, are included in $\sum \gamma X_{jor,t}$, such as labor productivity, among others.[22] FE_f is firm fixed effect and FE_t is year fixed effect. α is the intercept term, and $\varepsilon_{jor,t}$ is the error term.

[22] It is well-known in the literature that firms that are larger and more productive are more likely to export (e.g., Roberts and Tybout, 1997; Bernard and Jensen, 2004). We use labor productivity rather than total factor productivity because the information on value-added and intermediate

Similarly, we use equation (5) to estimate the impacts of subsidies along the value chains on export at the firm-product-destination level, using matched ASIF-Customs data.

$$y_{for,pdt} = \alpha + \beta_1 S_{fjor,t} + \beta_2 Up^1_{jor,t} + \beta_3 Up^2_{jor,t} + \sum \gamma X_{fjor,t} + FE_f + FE_{pdt} + \varepsilon_{jor,pdt} \quad (5)$$

where $y_{for,pdt}$ is denotes the export performance (entry, value, quantity, price, and quality defined previously) of firm f (of sector j ownership o in province r) product p to destination d for the year t. We include a set of three-way fixed effects. FE_{pdt} to control for product-destination-year-level varying factors such as tariffs, business cycles, import-demand shocks, and multilateral trade resistance (as highlighted by Head and Mayer, 2014). For both equations, we expect a positive relationship between industrial subsidies (direct and indirect) and firms' export performance.

5. Results

5.1 Subsidy and export margins

Table 3 reports the estimation results of equation (4). The results demonstrate a positive and statistically significant effect of *direct* subsidies on export participation (columns 1-4). These results suggest that direct subsidies are pivotal in expanding the extensive margin of Chinese firms' exports. It signifies an increase in the number of firms engaging in export activities. These subsidies act as catalysts, encouraging more firms to participate in international trade. Beyond participation, direct subsidies also impact the intensive margin—the volume of exports per firm (columns 5-8). Firms receiving direct government support experience a surge in their export volumes. This implies that subsidized firms are entering the export market and exporting more goods. The effect on the intensive margin is larger than the extensive margin. These results of direct subsidies' trade effects are consistent with those of Girma, Gong, Gorg, and Yu (2008).[23]

Interestingly, we also find a positive and statistically significant effect of *indirect* subsidies, especially those in 1st-tier upstream industries, on both extensive margin (columns 1-4) and intensive margin (columns 5-8). Contrary to expectations, indirect subsidies—specifically those

inputs are missing in the ASIF data after 2008.

[23] These findings may be interpreted by Arkolakis (2008), who develops a model in which firms incur a market penetration cost for exporting (advertising cost). This cost is not fixed but increases with the number of foreign consumers firms want to reach in the export market. Less productive firms may still enter export market but they can sell very small amounts. By contrast, more productive firms can afford more advertising cost and, hence, can export larger quantities. In this context, a production-related subsidy would be expected to have a smaller effect on the extensive margin, but a larger effect on the intensive margin, by helping existing exporters to afford the higher market penetration cost and expand their sales in the export market.

originating from 1st-tier upstream industries—have even greater effects than direct subsidies on China's exports. These upstream subsidies, channeled through supply chains, contribute significantly to export growth because they influence individual firms and the entire production and distribution networks.

Table 3. Subsidy and export margins: Firm-level, 1998-2013

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	exporter	exporter	exporter	exporter	exports	exports	exports	exports
subsidy	0.00454***	0.00452***	0.00452***	0.00452***	0.0496***	0.0495***	0.0495***	0.0495***
	(0.000107)	(0.000107)	(0.000107)	(0.000107)	(0.00103)	(0.00103)	(0.00103)	(0.00103)
subsidy_up1		0.159***	0.180***			1.497***	1.444***	
		(0.0153)	(0.0176)			(0.128)	(0.146)	
subsidy_up2			-0.00989***				0.0253	
			(0.00335)				(0.0289)	
subsidy_up1_D				-0.120*				1.758***
				(0.0668)				(0.599)
subsidy_up2_D				0.000636				-0.0330
				(0.00383)				(0.0375)
subsidy_up1_F				0.303***				1.247***
				(0.0319)				(0.271)
subsidy_up2_F				-0.0135*				0.237***
				(0.00770)				(0.0597)
productivity	0.00556***	0.00556***	0.00556***	0.00557***	0.152***	0.152***	0.152***	0.152***
	(0.000317)	(0.000317)	(0.000317)	(0.000317)	(0.00302)	(0.00302)	(0.00302)	(0.00302)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	3534556	3534556	3534556	3534556	3534556	3534556	3534556	3534556
adj. R-sq	0.733	0.733	0.733	0.733	0.768	0.768	0.768	0.768

Notes: Dependent variables: exporter dummy and log export value. ASIF 1998-2013 sample. Standard errors are clustered at the firm level. Significance levels: * 0.10 ** 0.05 *** 0.01

As our subsidy data in 2009, 2010, and 2012 are estimated values, we alternatively use the ASIF 1998-2007 data for robustness checks. The estimation results are reported in Table 4. We consistently find positive and statistically significant effects of direct and indirect (1st-tier upstream) subsidies on export margins. In addition, the indirect impacts of 2nd-tier upstream subsidies turn out to be positive and statistically significant, suggesting the spillover effects through supply chains. However, in both tables, the indirect impact of subsidies on export margins is a bit mixed and not clear-cut if we decompose the indirect subsidies to those for domestic firms and those for FIEs. These results suggest the nuanced impact of indirect subsidies, which deserves further investigation.

Table 4. Subsidy and export margins: firm-level, 1998-2007

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	exporter	exporter	exporter	exporter	exports	exports	exports	exports
subsidy	0.00476***	0.00473***	0.00471***	0.00469***	0.0542***	0.0540***	0.0538***	0.0537***
	(0.000172)	(0.000172)	(0.000172)	(0.000172)	(0.00162)	(0.00162)	(0.00162)	(0.00162)
subsidy_up1		0.307***	0.170***			2.052***	1.305***	
		(0.0232)	(0.0338)			(0.192)	(0.289)	
subsidy_up2			0.0877***				0.478***	
			(0.0154)				(0.136)	
subsidy_up1_D				0.610***				3.167***
				(0.125)				(1.106)
subsidy_up2_D				-0.0133				-0.270
				(0.0188)				(0.169)
subsidy_up1_F				-0.0121				0.380
				(0.0430)				(0.376)
subsidy_up2_F				0.333***				2.455***
				(0.0284)				(0.242)
productivity	0.0114***	0.0114***	0.0114***	0.0114***	0.215***	0.215***	0.215***	0.215***
	(0.000443)	(0.000443)	(0.000443)	(0.000443)	(0.00410)	(0.00410)	(0.00410)	(0.00410)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	1853724	1853724	1853724	1853724	1853724	1853724	1853724	1853724
adj. R-sq	0.734	0.734	0.734	0.734	0.774	0.774	0.774	0.774

Notes: Dependent variables: exporter dummy and log export value. ASIF 1998-2007 sample. Standard errors are clustered at the firm level. Significance levels: * 0.10 ** 0.05 *** 0.01

5.2 Heterogeneous effects by ownership

FIEs account for approximately half of China's total exports in the 2000s. To examine the possible heterogeneity among ownerships, we divide our sample into domestic and foreign firms. Tables 5 and 6 reveal that direct subsidies stimulate the extensive and intensive margins of both types of firms, and the effects are quantitively similar. As for indirect subsidies, the impact is nuanced: upstream subsidies exhibit heterogeneous effects based on ownership structures. Different types of firms—whether domestically owned or foreign-owned—respond differently to these subsidies. Domestic firms benefit from both 1st-tier and 2nd-tier indirect subsidies, while foreign firms benefit from 2nd-tier only, suggesting the possible competition between domestic firms and FIEs in the domestic inputs market. This nuanced relationship underscores the need for tailored policy interventions.

Table 5. Subsidy and export margins: Ownership, 1998-2013

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	exporter	exporter	exporter	exporter	exports	exports	exports	exports
	Domestic		Foreign		Domestic		Foreign	
subsidy	0.00413***	0.00413***	0.00456***	0.00456***	0.0440***	0.0440***	0.0584***	0.0584***
	(0.000119)	(0.000119)	(0.000237)	(0.000237)	(0.00112)	(0.00112)	(0.00236)	(0.00236)
subsidy_up1	0.221***	0.248***	-0.148***	-0.191***	1.941***	1.999***	-1.239***	-1.825***
	(0.0167)	(0.0190)	(0.0359)	(0.0468)	(0.137)	(0.156)	(0.335)	(0.434)
subsidy_up2		-0.0127***		0.0192		-0.0284		0.263**
		(0.00345)		(0.0129)		(0.0305)		(0.123)
productivity	0.00468***	0.00468***	0.00861***	0.00860***	0.103***	0.103***	0.390***	0.390***
	(0.000320)	(0.000320)	(0.000945)	(0.000945)	(0.00295)	(0.00295)	(0.00935)	(0.00935)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	2802299	2802299	722941	722941	2802299	2802299	722941	722941
adj. R-sq	0.687	0.687	0.686	0.686	0.724	0.724	0.726	0.726

Notes: Dependent variables: exporter dummy and log export value. ASIF 1998-2013 sample. Standard errors are clustered at the firm level. Significance levels: * 0.10 ** 0.05 *** 0.01

Table 6. Subsidy and trade margins: Ownership, 1998-2007

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	exporter	exporter	exporter	exporter	exports	exports	exports	exports
	Domestic		Foreign		Domestic		Foreign	
subsidy	0.00432***	0.00430***	0.00496***	0.00492***	0.0476***	0.0475***	0.0625***	0.0622***
	(0.000191)	(0.000191)	(0.000377)	(0.000377)	(0.00177)	(0.00177)	(0.00368)	(0.00368)
subsidy_up1	0.397***	0.280***	-0.312***	-0.601***	2.804***	2.151***	-3.596***	-5.762***
	(0.0251)	(0.0356)	(0.0615)	(0.0975)	(0.205)	(0.300)	(0.562)	(0.892)
subsidy_up2		0.0755***		0.173***		0.421***		1.299***
		(0.0163)		(0.0432)		(0.141)		(0.399)
productivity	0.0102***	0.0102***	0.0168***	0.0168***	0.157***	0.157***	0.508***	0.508***
	(0.000453)	(0.000453)	(0.00129)	(0.00129)	(0.00407)	(0.00407)	(0.0124)	(0.0124)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	1454751	1454751	392118	392118	1454751	1454751	392118	392118
adj. R-sq	0.687	0.687	0.689	0.689	0.729	0.729	0.736	0.736

Notes: Dependent variables: exporter dummy and log export value. ASIF 1998-2007 sample. Standard errors are clustered at the firm level. Significance levels: * 0.10 ** 0.05 *** 0.01

5.3 Subsidy, price, and quality

Table 7 reports the estimation results of equation (5) regarding the impacts of subsidies on export margins at the firm-product-destination level. After controlling for firm productivity, firm fixed effects, and product-destination-year fixed effects, the coefficients of direct subsidies are statistically significant for all outcome variables. The impact of direct subsidies on extensive margin (entry) and intensive margins (export value and quantity) are quantitively similar, which are different from firm-level results. One possible interpretation is that our matched ASIF-Customs data contains relatively large exporters only, and the market penetration cost for exporting and selling amounts at that market makes no difference at the firm-product-destination level after controlling for firm productivity. Furthermore, the indirect effects of subsidies in upstream industries on extensive margin are mixed, and its impact on intensive margin is unimportant.

Table 7. Subsidy and trade margins: Firm-product-destination-level

	(1)	(2)	(3)	(4)	(5)	(6)
	entry	entry	value	value	quantity	quantity
subsidy	0.0120***	0.0120***	0.0124***	0.0124***	0.0116***	0.0116***
	(0.000127)	(0.000127)	(0.000644)	(0.000644)	(0.000659)	(0.000659)
subsidy_up1		-0.289***		0.117		-0.158
		(0.0208)		(0.104)		(0.107)
subsidy_up2		0.0221***		-0.0229		-0.00407
		(0.00606)		(0.0269)		(0.0284)
productivity	0.0327***	0.0326***	0.103***	0.103***	0.0796***	0.0796***
	(0.000400)	(0.000400)	(0.00212)	(0.00212)	(0.00217)	(0.00217)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Destination-product-year FE	Yes	Yes	Yes	Yes	Yes	Yes
N	10313270	10313270	4931475	4931475	4931475	4931475
adj. R-sq	0.211	0.211	0.644	0.644	0.758	0.758

Notes: Dependent variables: entry dummy, log export value, and log export quantity. ASIF-Customs matched sample 2000-2012. Standard errors are clustered at the firm level. Significance levels: * 0.10 ** 0.05 *** 0.01

Table 8 shows that both direct and indirect subsidies, especially 1st-tier upstream, lead to a significant increase in export price and improvement in product quality. The positive effect on export prices is surprising as one may expect that subsidies will result in a significant reduction in production costs and lower export prices. However, a price increase accompanied by larger

export sales (both value and quantity) implies the role of quality. Indeed, we find statistically significant evidence of quality upgrading. Our results show a substantially larger effect on the estimated product quality than that on unit value, suggesting firms increase both quality and production efficiency. The net welfare effect on foreign consumers is shown through the negative coefficient on quality-adjusted prices. In other words, in the presence of subsidies, foreign consumers can obtain a better-quality product with the same amount of money. Directly subsidized firms can invest in R&D and quality control, producing high-quality exports. This is crucial for maintaining competitiveness in global markets. On the other hand, indirectly subsidized firms may obtain high-quality or low-price intermediate inputs from upstream industries.

Table 8. Subsidy and product quality: Firm-product-destination-level

	(1)	(2)	(3)	(4)	(5)	(6)
	price	price	quality	quality	quality_adjused price	quality_adjused price
subsidy	0.000848***	0.000856***	0.0158***	0.0158***	-0.0150***	-0.0150***
	(0.000299)	(0.000300)	(0.00146)	(0.00146)	(0.00120)	(0.00120)
subsidy_up1		0.275***		1.219***		-0.944***
		(0.0408)		(0.204)		(0.170)
subsidy_up2		-0.0189*		-0.0984**		0.0796*
		(0.0102)		(0.0497)		(0.0415)
productivity	0.0234***	0.0235***	0.197***	0.197***	-0.173***	-0.173***
	(0.00100)	(0.00100)	(0.00489)	(0.00489)	(0.00400)	(0.00400)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Destination-product-year FE	Yes	Yes	Yes	Yes	Yes	Yes
N	4931475	4931475	4931475	4931475	4931475	4931475
adj. R-sq	0.906	0.906	0.703	0.703	0.730	0.730

Notes: Dependent variables: log unit value, log product quality, and log quality-adjusted unit value. ASIF-Customs matched sample 2000-2012. Standard errors are clustered at the firm level. Significance levels: * 0.10 ** 0.05 *** 0.01

5.4 Discussion: Subsidy and firm investment

Recent literature has emphasized the importance of firm investment in technology upgrading for successful exporting. Using regional variations in the 2004 value-added tax pilot reform in China, which generated positive investment shocks, Liu and Lu (2015) show that firm investment significantly and substantially increases the likelihood of exporting. Investment and exporting

decisions are jointly determined. Using firm-level data, we examine the effects of subsidies on firm investment and R&D expenditure. We focus on the period of 2001-2010 as both outcome variables are available. The estimation results are reported in Table 9. In columns 1-3, we find a positive and statistically significant effect of direct subsidy on firm investment. Meanwhile, the impact of upstream subsidies is negative. One possible explanation is that downstream firms do not tend to invest if they can source high-quality and/or low-price intermediate inputs from upstream firms. In columns 4-6, we find similar results on the effects of subsidies on R&D expenditure. These results suggest that direct subsidies enhance export performance through investment and R&D activity, while indirect subsidies stimulate export activity through supply chains.

Table 9. Subsidy and investment: Firm-level, 2001-2010

	(1)	(2)	(3)	(4)	(5)	(6)
	investment	investment	investment	R&D	R&D	R&D
subsidy	0.0750***	0.0752***	0.0753***	0.103***	0.103***	0.103***
	(0.00165)	(0.00166)	(0.00166)	(0.00112)	(0.00112)	(0.00112)
subsidy_up1		-1.603***	-0.919***		-1.030***	-0.834***
		(0.205)	(0.273)		(0.0821)	(0.107)
subsidy_up2			-0.318***			-0.0911***
			(0.0919)			(0.0340)
productivity	-0.0667***	-0.0659***	-0.0657***	-0.0453***	-0.0449***	-0.0448***
	(0.00503)	(0.00503)	(0.00503)	(0.00260)	(0.00260)	(0.00260)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
N	2343243	2343243	2343243	2343243	2343243	2343243
adj. R-sq	0.140	0.140	0.140	0.535	0.535	0.535

Notes: Dependent variables: log capital investment and log R&D expenditure. ASIF 2001-2010 sample. Standard errors are clustered at the firm level. Significance levels: * 0.10 ** 0.05 *** 0.01

6. Conclusion

Using a unique dataset from the Chinese industrial sectors, this paper analyses the impacts of industrial subsidies along value chains on firms' export performance. It documents strong evidence that (1) Direct subsidies significantly stimulate export participation (extensive margin) and export volume (intensive margin). (2) Upstream (indirect) subsidies have even larger effects on China's exports than direct subsidies. (3) Upstream subsidies have heterogeneous effects by

ownership. (4) Both direct and indirect subsidies lead to higher export prices and product quality but lower quality-adjusted prices, suggesting a net welfare-enhancing effect for foreign consumers. These export growth and quality upgrading are driven by direct subsidies through increased investment and R&D expenditure and indirect subsidies through intermediate inputs. Understanding the multifaceted effects of subsidies along value chains is essential for policymakers, industry stakeholders, and researchers. By dissecting these findings, we contribute to the ongoing debate on industrial subsidy policies and their implications for China's export growth.

We are cautious to point out, however, that we find positive impacts of industrial subsidies on export activities at the firm level (and firm-product-destination level)—we have nothing to say about whether these policies are beneficial or harmful to foreign firms in the global market. Foreign firms that rely on intermediate inputs from China may benefit, while those directly competing with Chinese exporters may lose. Another challenging question is the cost-benefit and welfare implications of such subsidies to the Chinese economy as a whole since there are subsidies misallocation in China (e.g., Wei, Zhuan, Zhang 2017). These questions clearly deserve further theoretical and empirical investigation.

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Appendix

Table A1. Summary statistics: ASIF

Variable	Mean	Std. dev.	Min	Max
exporter dummy	0.254	0.435	0	1
log exports	2.405	4.219	0	12.545
subsidy	322	9,445	0	5,794,491
log labor productivity	5.389	1.139	-8.177	8.217
log sales	10.309	1.466	0.000	19.840
profitability	0.034	0.108	-0.534	0.397
log wage	7.495	1.410	0.000	22.402
log firm age	2.008	0.766	0.000	3.584
SOE dummy	0.060	0.237	0.000	1.000
FIE dummy	0.202	0.401	0	1

Notes: ASIF 1998-2013 sample. N=3,889,180. Source: Authors' compilation based on the ASIF.

Table A2. Summary statistics: China Customs

Variable	Obs	Mean	Std. dev.	Min	Max
subsidy	11,521,923	2,192	58,998	0	5,794,491
entry	11,521,923	0.501	0.500	0	1
log value	5,768,605	3.458	2.377	-3.079	8.761
log quantity	5,768,605	8.477	3.038	0.693	15.095
log price	5,768,605	-5.031	2.021	-9.536	2.473
quality	5,768,605	1.333	5.179	-13.490	17.439
quality adjusted price	5,768,605	-6.369	4.573	-18.585	7.197
log labor productivity	11,521,923	3.532	0.988	1.485	6.442

Notes: ASIF-Customs matched sample 2000-012. Source: Authors' compilation based on China Customs.

Table A3. Summary statistics: Upstream subsidies

Variable	Mean	Std. dev.	Min	Max
subsidy_up1	0.013	0.023	0	0.890
subsidy_up2	0.042	0.174	0	13.108
subsidy_up1_Domestic	0.005	0.011	0	0.890
subsidy_up2_Domestic	0.027	0.166	0	13.108
subsidy_up1_Foreign	0.007	0.017	0	0.578
subsidy_up2_Foreign	0.015	0.050	0	2.983

Notes: N=11,408. Source: Authors' compilation based on the ASIF and inter-provincial IO table.