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CHEN, Chen
Fuzhou University of International Studies and Trade

SALIKE, Nimesh
International Business School Suzhou

THORBECKE, Willem
RIETI

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Exchange Rates and Tariffs: Unravelling their impacts on China's ICT exports while accounting for product sophistication ※

Chen Chen*
International Business School,
Fuzhou University of International Studies and Trade

Nimesh Salike**
International Business School Suzhou

Willem Thorbecke***
Research Institute of Economy, Trade and Industry, Japan

Abstract
China's information and communication technology (ICT) exports have faced intense trade friction. To investigate why China's ICT industry has been targeted, this paper examines it before the Sino-U.S. trade war erupted. We first investigate whether changes in exchange rates and tariffs affect China's ICT exports differently depending on their sophistication levels. We estimate the exchange rate and tariff effects for 44 ICT HS 4-digit export categories included in Attachment A for the WTO Information Technology Agreement by employing high-dimensional fixed effects on bilateral trade data between China and 196 trading partners between 2003 and 2018. The results indicate that renminbi appreciations reduce ICT exports and that exchange rate elasticities are lower for more sophisticated products. Tariffs reduce exports much more than appreciations do, especially for highly sophisticated ICT exports. We also report product-level exchange rate elasticities for important ICT products and present an industrial development strategy.

Keywords: Chinese ICT exports, exchange rate elasticities, tariff effects, product sophistication, Information Technology Agreement
JEL classification: F10, F14, F13

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[*] Chen Chen. International Business School, Fuzhou University of International Studies and Trade. Fuzhou, China. Email: chenchen1@fzfu.edu.cn

[**] Nimesh Salike. International Business School Suzhou, Xi'an Jiaotong-Liverpool University. Suzhou, China. Email: Nimesh.Salike@xjtlu.edu.cn

[***] Willem Thorbecke. Research Institute of Economy, Trade and Industry, Tokyo, Japan. Email: willem-thorbecke@rieti.go.jp

1. Introduction

As China became a leading exporter of information and communication technology (ICT) products, its export basket evolved, but this progress also triggered significant trade frictions, with partner economies frequently imposing tariffs and other restrictions. Investigating China's ICT exports prior to 2018 is crucial, as this period offers valuable insights into the factors behind the U.S.'s decision to impose heavy sanctions on these industries. The analysis of exchange rate and tariff effects on these sectors before 2018 is particularly important in understanding the economic and geopolitical tensions that have shaped U.S.-China relations. Additionally, given the technological sophistication of many telecommunication products, it is essential to explore how exchange rates and tariffs have differentially impacted exports based on technological complexity. Such an investigation helps explain the role these factors played in fueling trade frictions and potentially decoupling these two economies.

Sophisticated goods that require relatively higher technological inputs are less ubiquitous than simple goods, implying that buyers may need more time to find substitutes (Hidalgo & Hausmann, 2009). For this reason, Abiad et al. (2018) noted that complex goods should have lower price elasticities of demand. Therefore, exchange rate may exert limited effects on export volumes for more sophisticated goods. This hypothesis is supported by empirical evidence (Arbatli and Hong, 2016; Thorbecke and Kato, 2018; Thorbecke and Salike, 2020; Thorbecke, Chen and Salike, 2021). There is little evidence, however, investigating the relationship between tariffs and product sophistication levels.

To examine how exchange rates and tariffs affect China's telecommunications exports, we select 44 major ICT Harmonized System (HS) 4-Digit categories. The ICT products are divided into 7 categories: computers, telecommunication equipment, semiconductors, semiconductor manufacturing and testing equipment, software, scientific instruments, and associated parts & accessories[1]. Most of the ICT products are highly sophisticated.[2] They are linked to influential, significant, and innovative industries such as artificial intelligence, 4G, 5G, internet banking, and modern manufacturing. ICT products also undergird services and digital trade. Thus, these products figure prominently in trade disputes.

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[1] Refer WTO (2022) for more detailed list of products.

[2] Detailed classification can be found in Table 6.

ICT products are crucial for China. The growth of ICT products benefits China by directly promoting China's economic growth and improving knowledge diffusion, productivity growth, and economic innovation (Ezell & Atkinson, 2014).

Figure 1 Panel A presents the share of important ICT products in China's total exports. Among the major ICT products, computers have been China's leading export category since 2000, averaging 8% of China's exports between 2003 and 2018. Since 2006, ICT products have been the top export categories in China; these products include computers; parts and accessories for office machines; transmission devices for radio, telephone, and TV; parts of radios, telephones, and TVs; and telephones.[3]

Figure 1 Panel B presents China's share of world exports for selected important ICT products. China has become the major ICT exporter in the world market. For instance, the exports of computers from China have accounted for 50% of the world computer market since 2010. Telephones have comprised more than 40% of the world market since 2015. China is currently the largest ICT product exporter globally.

Figure 1 Panel C presents the share of all 44 ICT products aggregated together in China's total exports. All ICT products represent a large share of China's total exports. These products increased from 26.5% of China's total exports in 2003 to 32.5% in 2018.

Both exchange rate and tariff may affect exports and are thus worth investigating for this important industry. The international elasticity puzzle suggests that tariff increases deter exports more than exchange rate appreciations do (see, e.g., Bénassy-Quéré et al., 2021, Fontagné et al., 2018, and Fitzgerald and Haller, 2014). However, some WTO agreements have reduced or even eliminated customs duties in certain sectors. One such initiative is the Information Technology Agreement (ITA). Established in 1996, the ITA has reduced or eliminated tariffs on ICT products. For instance, the U.S. tariff rate on computers decreased from 1.09% in 1996 to 0% in 1999, and it has remained duty-free up to 2018, the last year of our sample, for ITA participants and other most favored nations (MFNs). Similarly, Japan and the EU's tariff rates on computers were reduced to 0% over the 1996 to 2018 period.[4] China joined the ITA in 2003 and became one of its largest beneficiaries.

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[3] Statistical data can be found on the Atlas Economic Complexity website https://atlas.cid.harvard.edu/

[4] Tariff data are acquired from the WITS dataset for the weighted-average tariff rate.

Figure 1 (Panel A): China's top 8 ICT product export share

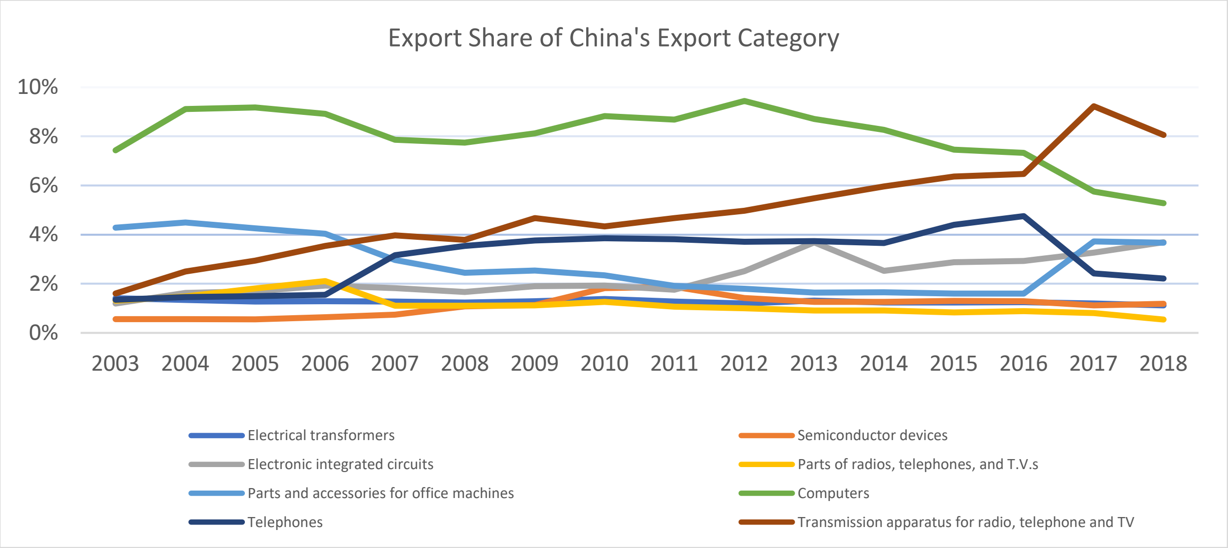


Figure 1 (Panel B): World Market Share of China's Selected ICT Products

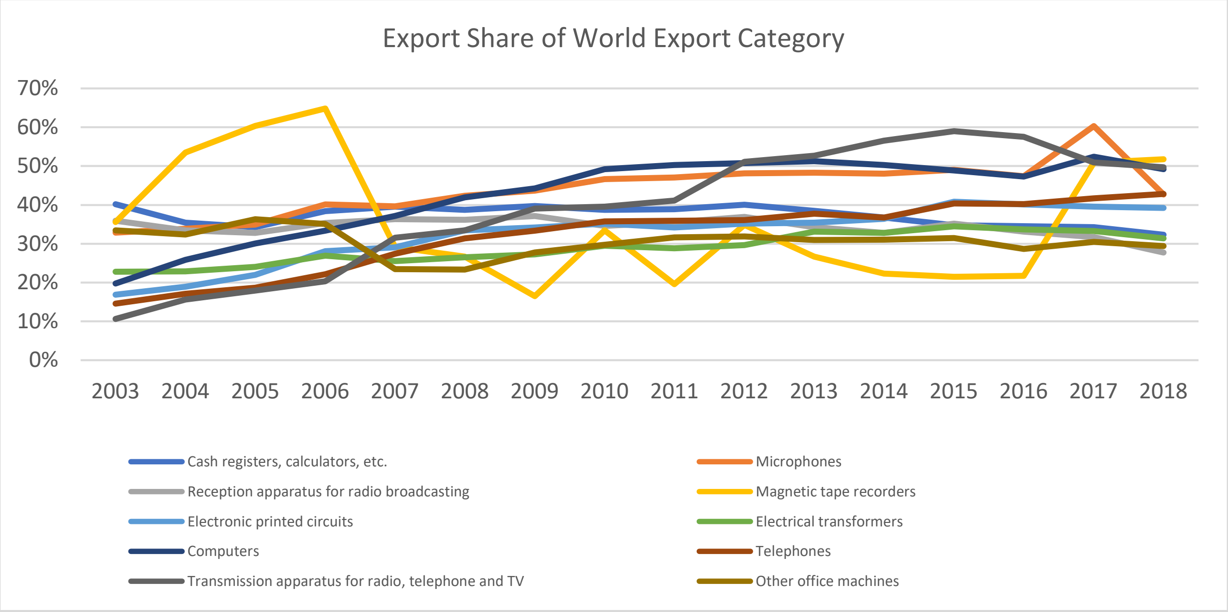
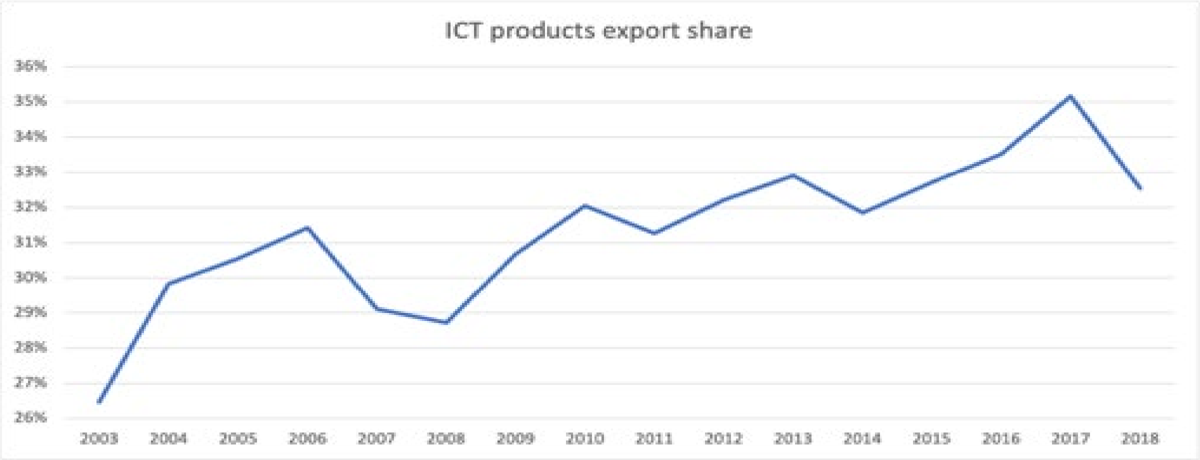


Figure 1 (Panel C): Export Share of China's Export Basket for 44 ICT Products



In this paper, we analyze how exchange rates and tariffs influence China's ICT exports while taking account of the sophistication levels of these products. We then examine 44 Chinese ICT export categories, in accordance with the HS 4-digit products that are included in Attachment A of the ITA, to 196 trade partners over the period 2003–2018.[5] We classify product sophistication using Hidalgo and Hausmann's (2007, 2009 & 2014) measurement of the product complexity index (PCI). We follow Bénassy-Quéré et al. (2021) in using fixed-effects estimation. We report results for individual ICT products.

The next section reviews the literature. Section 3 introduces ITA and ICT products in detail. Section 4 discusses the theoretical model, data, and methodology. Section 5 reports the results. Section 6 provides an in-depth analysis of China's telecommunication industry from the product space perspective. Section 7 provides policy implications and concludes.

2. Literature Review

Weaker exchange rates should increase exports. Some studies found that a 10% depreciation in the real effective exchange rate (REER) increases exports by 6-8% (Ahmend, Appendino & Ruta, 2015; Eichengreen & Gupta, 2013; Freund & Pierola, 2012; Garayeva & Tahirova, 2017). Bénassy-Quéré et al. (2021) reported that a 10% REER depreciation increases exports by 5%. For China, Xing (2018) reported that a 10% appreciation of the yuan against the U.S. dollar reduces processed exports by 3% and Fatum et al. (2018) and Thorbecke (2015) found that yuan depreciations increase exports by various amounts. Research also highlights the impact of institutional quality on exchange rate effects, where

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[5] Only Attachment A, which includes HS code information, is relevant to the study. Attachment B contains the product details.

better institutions enhance the responsiveness of exports (Garayeva & Tahirova, 2017), and how developing countries' manufacturing exports are more stimulated by currency depreciations (Freund & Pierola, 2012). Additionally, Eichengreen & Gupta (2013) found evidence across 66 countries that a 10% depreciation increases merchandise exports by 1.5% and services exports by 2.3%. Thorbecke and Salike (2020) reported lower exchange rate effects for high-tech products and for advanced economies. Arbatli & Hong (2016) and Thorbecke and Kato (2018) reported that products with higher sophistication levels respond less to exchange rates.

The negative effect of tariffs on exports is well documented, including for studies of China's exports (Bénassy-Quéré et al., 2021; Xu et al., 2020). Tariff reductions can enhance scale and efficiency in industries with previously high protection, as firms expand output per plant (Head & Ries, 1999). Tariffs on intermediate goods disrupt global supply chains by raising input prices, leading to renegotiation of contracts or searches for new suppliers. This can cause a deterioration in the terms of trade and result in higher production costs, particularly in industries with elastic demand for differentiated products (Grossman & Helpman, 2021). U.S. tariff increases between 2018 and 2019 negatively impacted export growth, especially for goods involved in global supply chains, with larger effects in 2019 (Handley, Kamal, & Monarch, 2020). Higher tariffs mean higher costs for importing countries to purchase goods, which often results in a decrease in demand. Consequently, exporters face reduced orders and a decline in export volumes.

However, few studies have examined the exchange rate and tariff effects for ICT exports from China. This study considers product sophistication in evaluating the exchange rate and tariff elasticities for China's ICT exports. Further, we use the product space framework of Hidalgo & Hausmann (2007) to analyze the development path of China's telecommunication industry.

3. ITA, ICT Products, and China's Exports of ICT Products

The original ITA was established at the WTO Singapore Ministerial Conference through a "Ministerial Declaration on Trade in Information Technology Products" on 13 December 1996. The original ITA included 29 original signatories who were principal ICT product exporters and importers at the time.[6] The ITA now includes 81 WTO members

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[6] Australia, Indonesia, Singapore, Canada, Japan, Switzerland, European Communities (15 member states), Korea, Turkey, Hong Kong, Norway, United States, Iceland, Taiwan.

(including China), comprising nearly 97% of world trade of ICT products, and about 90% of ICT products are duty-free (Tang, 2017).[7] The Participants are required by the ITA to eliminate and bind customs duties at zero for ICT products specified in the ITA, and this tariff elimination is implemented on an MFN basis. Thus, countries that have not joined the ITA can also benefit from the ITA.

The products covered in the ITA fall into seven main categories: (i) computers, (ii) telecommunications equipment, (iii) semiconductors, (iv) semiconductor manufacturing and testing equipment, (v) software, (vi) scientific instruments, and (vii) associated parts and accessories.[8] The original ITA lists the covered products using Attachments A and B. Attachment A provides the products with HS1996 subheadings, most of which are in disaggregated to the HS 6-digit level. Attachment B lists the products by name, particularly those without HS codes. Thus, Attachment B overlaps with the HS codes listed in Attachment A. The original ITA included 203 products; however, ICT products and industries are the most innovative. Products covered in the original ITA products no longer represent core ICT products. Thus, important expansion negotiations agreed to in 2015 have 201 additional products, accounting for 10% of world trade in goods before the expansion. Products covered are new-generation multicomponent integrated circuits, touchscreens, GPS navigation equipment, portable interactive electronic education devices, video game consoles, and medical equipment.[9] WTO predicted 100% duty-free conditions for all participants and MFNs by 2022. No expansion negotiation is expected after this 2015 expansion agreement.

China joined the WTO in December 2001 and subsequently participated in the ITA in 2003. Information and communication technologies have been the primary driver of Chinese economic growth for almost two decades. The contribution of ICT products to China's GDP growth remained constant at nearly 20% from 2003 to 2007 (Wang and Lin, 2013). China becoming the leading player among IT technology producers and users is because of the rapid growth of ICTs. This growth is not only realized through ICT production but also through ICT consumption and usage (Atkinson et al., 2011). Production and consumption promote productivity and innovation across all industries. ICT production and consumption achieve

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[7] More details on WTO (2022).

[8] Main products are listed in Appendix 1.

[9] Briefing note: The Expansion of Trade in Information Technology Products (ITA Expansion).

https://www.wto.org/english/news_e/news15_e/itabriefingnotes161215_e.pdf this status by creating the modern economy's general-purpose technology (GPT). GPT touches all industries easily, experiences price decline, and steadily improves performance. It provides benefits from the possibility of inventing and producing new products (e.g., smartphones), processes (e.g., WeChat pay or Apple Pay), business models (e.g., e-business models), and even fundamentally new inventions (e.g., VR) (Atkinson and Mckay, 2007& Ezell and Atkinson, 2014).

ICT products are relatively sophisticated, and the resources used for producing ICT products normally are used for other production process as well. ICT products as a whole can serve as the important foundation for inventing new technologies and further industrial development. As China devotes its capabilities and formulates policies concerning ICTs, its product space (Hidalgo and Hausmann, 2007) has evolved from the cluster of textile and light manufacturing to relatively high-end ICTs. This evolution and upgrading have helped China improve its export basket to become more sophisticated. China has also become the largest exporter of ICT products worldwide. The export share of ICTs in China's overall export value has increased over the years.[10] China has benefitted from its participation in the ITA. Its share in global ICT exports was merely 2% in 1996 when ITA was implemented and increased to 27% in 2010; ultimately it has become the leading country in ICT exports. Thus, China's ICT exports are essential to the Chinese economy. Because tariff rates fell to zero, exchange rates became a key factor that might affect ICT exports. Investigating the exchange rate elasticities of ICT products may shed light on how this sector evolved.

4. Theoretical Model, Data, and Methodology

4.1. Theoretical Model

Following the imperfect substitutes model of trade flows (Goldstein & Khan,1985; Rose,1991; and Chinn, 2004 & 2005), our theoretical model links bilateral real exchange rate (BRER) and tariffs with changes in trade flows. We then extend this model to investigate how exchange rates and tariffs affect exports of different sophistication levels. Complex products tend to exhibit lower import price elasticities because relatively fewer substitutes exist (Thorbecke, Chen & Salike, 2021). In such a case, the imperfect substitutes model

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[10] Information on the world share of ICT exports and the export share to China's exports is presented in Appendix 1.

implies that the exchange rate elasticities should also be lower for more complex products.[11] Similarly, this limited sensitivity should apply to the effect of tariffs on sophisticated products. However, compared to exchange rates, tariffs are more frequently used as tools for trade retaliation, particularly for sophisticated products.

Following Chinn (2004, 2005), we model China's exports as a function of the aggregate national income (Y) of the importing economy j, relative import prices between economy *j*'s currency and the Chinese yuan (P_{im}^{j}), and the export price in Chinese yuan relative to *j*'s currency (P_{ex}^{c}).

$$X^{c} = f\left(Y^{j}, P_{im}^{j}, P_{ex}^{c}\right) \qquad (1)$$

The relative price P_{im}^{j} and P_{ex}^{c} are strongly influenced by exchange rate and tariff pass-through. Therefore, Equation (1) can be written in log-linear form as:

$$lnX^{c} = \alpha + \beta_1 lnBRER + \beta_2 \ln\ Tariff + \beta_3 Y^{j} \qquad (2)$$

Equation (2) shows that China's exports depend on bilateral real exchange rates and tariffs between China and its trading partners and on the importing economy's real GDPs. The parameter β_1 is the exchange rate elasticity of exports; its expected sign is negative as an increase in BRER represents a renminbi appreciation. β_2 is expected to be negative and β_3 is expected to be positive.

As previously mentioned, complex products have fewer substitutes. Thus, price changes should the quantity demanded of sophisticated exports less. According to Chen and Juvenal (2016) and Berman et.al (2012), the exchange-rate pass-through is less for higher-quality products. The exchange rate effect tends to be limited for more sophisticated products because both exchange-rate pass-through and exchange rate elasticity are limited for more sophisticated products. Thus, we should expect a smaller change in exports for more sophisticated products when the exchange rate fluctuates.

Cavallo et al. (2021) show that tariffs in the U.S. on imports, especially from China, are mostly passed through to prices. However, the degree of pass-through differs across sectors, with products that are more technologically sophisticated (such as electronics) seeing smaller price increases at the retail level compared to basic goods. Hayakawa et al. (2021) highlighted that, when tariffs are reduced, product quality decreases by 1.6%, suggesting that tariffs may induce a "quality-sorting" effect. For higher-quality or more sophisticated goods, tariffs can lead to an increase in the quality-adjusted prices because producers may not want

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[11] Please see Chen, Salike and Thorbecke (2023) for a detailed discussion.

to downgrade the quality of premium products. This results in a paradox where tariff reductions may lower the gross prices but raise the quality-adjusted prices. Thus, the tariff effects for more sophisticated products are somehow ambiguous.

4.2. Variables and Descriptive Statistics

Key variables used for this study include product level export data, bilateral real exchange rate, bilateral tariff rate, the product complexity index (PCI), and other macroeconomic variables. We use a high-dimensional panel format that includes one exporting country (China) with 196[12] trading partners over 15 years (2003–2018)[13] disaggregated into 44 ICT categories at the HS 4-digit level. In principle this could generate more than 124,000 observations. However there are gaps in the trade data reported by some countries. Therefore the database is unbalanced.

Data on the bilateral export value (X*jpt*) between China and its trading partners are collected from the Harvard University Growth Lab (https://growthlab.cid.harvard.edu/atlas-economic-complexity). These data originally come from UN Comtrade database and measure bilateral FOB export values (in US dollars) from China to its trading partners. We deflate the FOB export value using CPI in each year and transform the U.S. dollar to Chinese yuan. The data provide paired relationships for China-importer-HS 4-digit products in different years. The list of trading partners, along with the frequency of associated observations, is available in Appendix 2. Data on bilateral export volume (XQ*jpt*) are collected from UN Comtrade. Both the deflated export value in yuan and the export volume contain zero values; thus, we use ln(X+1) for log transformation to avoid missing values.

BRER*jt* data are collected from CEPII (http://www.cepii.fr/cepii/en/bdd_modele/bdd.asp). An increase in the bilateral real exchange rate represents a real appreciation of the Chinese yuan. The bilateral real exchange rate between China and the partner economy was calculated using the U.S. dollar as the intermediary. Data on real GDP(Y*jt*), which is the GDP of the trading partners are also acquired from CEPII. Tariff data are collected from WITS-Trains Dataset, and we use ln(Tariff+1) for estimations.

Another key variable used in the study is PCI*pt*. The PCIs for all 44 HS 4-digit products are also collected from the Harvard University Growth Lab. Hidalgo, Hausmann,

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[12] We include all the trading partners of China because all of them enjoy MFN benefits regardless of being a participant of the ITA or not.

[13] 2003 is the year when China participated ITA.

and others (2007; 2014) published studies defining economic complexity and product sophistication. Qualitatively, economic complexity is an economy's ability to amass capabilities for exporting diverse and sophisticated products. Product sophistication is based on production non-ubiquity and complexity. Quantitatively, they used the reflection method with bipartite networks and bilateral trade data. In a sample bipartite network, more capabilities and non-ubiquity indicate higher sophistication. Since direct measurement of capabilities is difficult, the reflection method helps. To simplify, only exports with Revealed Comparative Advantage (RCA) are considered, defined by Balassa (1965). Diversification (number of products with RCA greater than 1 that an economy exports) and ubiquity (number of economies exporting a product with RCA) are used. An iterative “method of reflection” estimates the Economic Complexity Index (ECI) and Product Complexity Index (PCI).[14] For this paper, focusing on China's exports, PCI is calculated based on the average diversity of exporting economies and the average ubiquity of other products they make over the sample period. A higher PCI indicates a more sophisticated product.

Table 1 presents the descriptive statistics for the dependent variable and other explanatory variables. Our key variables of interest are the bilateral real exchange rate and tariff rates between China and its trading partners. Except for the PCI, all numerical variables are measured in natural logarithms.

Table 1. Summary statistics					
log transformed variables except for PCI*pt*					
	Observations	Minimum	Maximum	Mean	Std.Dev.
lnX*jpt*	107,990	0	20.29	8.58	3.47
lnXQ*jpt*	67,269	0	24.8	9.13	4.84
lnBRER*jt*	107,990	-1.52	1.18	-0.10	0.49
lnTariff*jpt*	108,259	0	0.997	0.048	0.064
lnY*jt*	107,990	17.32	30.63	24.62	2.16
PCI*pt*	107,990	-0.71	2.48	1.06	0.63

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[14] Please see Chen, Salike and Thorbecke (2023) for a detailed discussion.

Notes: For each variable listed in the first column, the table reports key descriptive statistics.

4.3. Empirical Methodology

The gravity model of trade is an established workhorse technique for explaining bilateral trade flows. Nonetheless, advanced models based on fixed effects have been developed, with other key variables included. We follow Bénassy-Quéré et al. (2021) and include a series of fixed effects in the trade model:

$$lnX_{ijpt} = \lambda_{ipt} + \mu_{jpt} + \nu_{ij} + \epsilon_{ijpt} \qquad (3)$$

where lnX_{ijpt} denotes the exports from economy *i* to economy *j* of product *p* during year *t*. λ_{ipt}, μ_{jpt}, and ν_{ij} are the fixed effects shown in the dimension indices, and ϵ_{ijpt} is the error term.

λ_{ipt}= 'exporter' 'product' 'time' fixed effects

μ_{jpt}= 'importer' 'product' 'time' fixed effects

ν_{ij}= 'exporter' 'importer' fixed effects

We follow Bénassy-Quéré et al. (2021) in adding the natural logarithm of the bilateral real exchange rate, $lnBRER_{ijt}$, and the natural logarithm of tariff rates, $lnTARIFF_{ijpt}$, of economy *i* against economy *j* of product *p* as follows:

$$lnX_{ijpt} = \beta lnBRER_{ijt} + \Phi lnTARIFF_{ijpt} + \lambda_{ipt} + \mu_{jpt} + \nu_{ij} + \epsilon_{ijpt} \qquad (4)$$

The empirical model used in this paper is a modified version of Equation (4). The fixed effects in this paper only have three dimensions (*j, p, t*) because there is only one exporting country, China. Following our theoretical model, we also add the logarithm of the real GDP of the importing countries as a control variable. We estimate the exchange rate effect without considering the sophistication levels of the products:

$$lnX_{jpt} = \alpha + \beta lnBRER_{jt} + \Phi lnTARIFF_{jpt} + \delta lnY_{jt} + \lambda_{pt} + \mu_{jpt} + \epsilon_{ijpt} \qquad (5)$$

We also include interaction terms—the bilateral real exchange rate interacted with PCI and the bilateral tariff rate interacted with PCI—to capture the effects for different sophistication levels, as our hypothesis indicates that products with different sophistication levels should exhibit different responses. Therefore, considering the different sophistication levels we estimate the following equation as our baseline regression:

$$\begin{aligned} lnX_{jpt} = \alpha &+ \beta_1 lnBRER_{jt} + \eta PCI_{pt} + \beta_2 lnBRER_{jt} \times PCI_{pt} + \Phi_1 lnTARIFF_{ijt} + \Phi_2 lnTARIFF_{ijt} \times PCI_{pt} + \delta lnY_{jt} \\ &+ \lambda_{pt} + \mu_{jpt} + \epsilon_{jpt} \qquad (6) \end{aligned}$$

We also include importer–product fixed effects and time fixed effects as additional controls. We prefer to include importer–product paired fixed effect and time fixed effect separately because exports can be influenced by preference of the destination economy. For example, the same computer exported from China might be more appealing in Japan than in the U.S. We expect the coefficients on both the bilateral real exchange rate and the tariff rate to be negative, the coefficient of real GDP to be positive, and the coefficient of the interaction term to be positive.

5. Results and Discussion

5.1 Baseline Results

Using Equation (5), we first estimate the baseline model including exchange rates and tariffs without considering product sophistication. It includes paired fixed effects of the importing economy and product (*jp*) and time (*t*) fixed effects separately, as shown in Column (1) of Table 2, Panel A for exchange rates and in column (4) for tariffs. We also offer sensitivity checks using other fixed effects such as the importing economy (*j*), product (*p*), and time (*t*) separately, and the importing economy(*j*) and product and time paired (*pt*) fixed effects, as shown in Columns (2) (3) for exchange rate and (5) (6) for tariff, Panel A. In Column (1), the coefficient on the bilateral real exchange rate is significant at the 1% level and equals -0.762, indicating that if China's currency appreciates by 10%, ICT exports decrease by 7.62%. In Column (4), the coefficient on the tariff rate is significant at the 1% level and equals -1.218, indicating that if the tariff rate for a specific product increases by 10%, exports of that product will decrease by 12.2%. These findings indicate that tariffs impact exports more than exchange rates do. Moreover, these results remain consistent across the other columns, despite differences in the fixed effects specifications. The coefficients on real GDP in the importing economy are significant at the 1% level and as expected have positive signs. They indicate that, when importing country real GDP in the importing economy increases by 10%, exports increase by 11-13%. In Columns (7), (8), and (9), we incorporate both exchange rates and tariff rates in the model. While there is a minor uptick in the magnitude of all the variables, the results remain consistent with our earlier findings. An appreciation of the exchange rate, as well as an increase in the tariff rate, both decrease exports of Chinese ICT products. The impact of tariffs remain substantially greater than the impact of exchange rates.

We also measure the exchange rate elasticity by using the export volume as the dependent variable. Columns (1), (2), and (3) in Table 2, Panel B, when analyzing the exchange rate, different fixed-effect specifications are employed, yet the results are quite similar, with only minor variations in magnitude. Regarding tariffs, the coefficients in Columns (4), (5), and (6) are mostly not statistically significant. The same is true for Columns (7), (8), and (9). In essence, this indicates that when the data are shifted from export value to export volume, the impact of tariffs becomes less apparent. On the other hand, the coefficient related to GDP of the importing country has the expected sign and is statistically significant.

Table 2. Baseline results using ln(X+1)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: *dependent variable is deflated export value in RMB-exchange rate and tariff effect*									
lnBRER*jt*	-0.762***	-0.727***	-0.697***				-0.778***	-0.761***	-0.752***
	-0.114	(0.112)	(0.115)				(0.129)	(0.128)	(0.129)
ln*TARIFF jpt*				-1.218*	-1.946***	-2.047***	-1.256*	-1.946***	-2.058***
				(0.691)	(0.580)	(0.556)	(0.641)	(0.563)	(0.542)
lnY*jt*	1.148***	1.111***	1.096***	1.380***	1.348***	1.311***	1.168***	1.144***	1.108***
	(0.152)	(0.148)	(0.152)	(0.226)	(0.221)	(0.225)	(0.220)	(0.214)	(0.218)
Constant	-19.80***	-18.89***	-18.51***	-25.26***	-24.44***	-20.50***	-20.08***	-19.45***	-18.56***
	(3.766)	(3.658)	(3.761)	(5.661)	(5.532)	(5.629)	(5.529)	(5.372)	(5.454)
Fixed Effects	jp-t	j-p-t	j-pt	jp-t	j-p-t	j-pt	jp-t	j-p-t	j-pt
Observations	144,304	144,484	144,482	100,649	100,942	100,938	100,192	100,482	100,479
Adjusted R-squared	0.836	0.768	0.803	0.879	0.805	0.826	0.880	0.806	0.827
Panel B *:dependent variable is export volume-exchange rate and tariff elasticity*									
lnBRER*jt*	-0.663***	-0.618***	-0.614***				-0.765***	-0.756***	-0.787***
	(0.174)	(0.164)	(0.174)				(0.214)	(0.209)	(0.227)
ln*TARIFF jpt*				0.123	-0.520	-1.026*	0.137	-0.496	-1.023*
				(0.725)	(0.624)	(0.592)	(0.668)	(0.603)	(0.577)
lnY*jt*	1.377***	1.338***	1.254***	1.807***	1.699***	1.634***	1.600***	1.498***	1.423***
	(0.241)	(0.234)	(0.246)	(0.379)	(0.365)	(0.398)	(0.386)	(0.370)	(0.404)
Constant	-25.14***	-24.15***	-22.08***	-35.78***	-33.04***	-31.38***	-30.75***	-28.15***	-26.24**
	(5.980)	(5.791)	(6.100)	(9.531)	(9.173)	(10.019)	(9.711)	(9.301)	(10.160)
Fixed Effects	jp-t	j-p-t	j-pt	jp-t	j-p-t	j-pt	jp-t	j-p-t	j-pt
Observations	97,179	97,483	97,470	66,432	66,864	66,852	66,206	66,637	66,625
Adjusted R-squared	0.563	0.519	0.651	0.607	0.557	0.671	0.608	0.558	0.672

Notes:Different paired fixed effects of Importing economy(*j*), product(*P*)and time(*t*) are included. Robust standard errors adjusted for clustering at the importing economy-level and product-level are reported in parentheses. '***','**',and'*' indicated significance at the one, five,and ten percent levels.

3

5.2 Results with Sophistication Levels

Subsequently, we incorporated PCI into the specification to examine whether products of varying sophistication levels have heterogeneous effects. In these estimates, the product sophistication level is measured by PCI_{pt}, which ranges from -0.955 to 2.605. This variable is not log-transformed because it takes on negative values. Table 3 lists the descriptive statistics for the PCI.

Table 3. Descriptive statistics of PCI			
Percentiles	PCI Value	Obs. No.	146362
0	-0.96	Sum of Weights	146362
0.01	-0.55		
0.05	-0.18		
0.1	0.12		
0.25	0.61		
0.5	1		
0.75	1.56	Mean	1.021
0.9	1.86	Std.Dev	0.671
0.95	2.06	Variance	0.451
0.99	2.36	Skewness	-0.234
1	2.61	Kurtosis	2.621
Note: Higher PCI values indicate higher level of sophistication of product			

To examine how sophistication levels influence the exchange rate and tariff effects on the deflated export value in yuan, we use Equation (13) for estimation. The results are presented in Table 4. Panel A presents the results for export values. In Columns (1), (2), and (3), the effects of the exchange rate are shown under different levels of fixed-effects sensitivity. Columns (4), (5), and (6) display the effects of the tariff rate. When we focus on Columns (7), (8), and (9), where both the exchange rate and the tariff rate are included in the analysis, the outcomes are somewhat inconsistent. While the results for the exchange rate remain stable, with signs and significance levels falling within what was anticipated, the results for the tariff rate vary in terms of both their signs and significance.

Firstly, in regard to exchange rate effects, the positive sign of the coefficient for the interaction term between PCI and bilateral real exchange rate, indicates that for 1 unit increase in PCI*pt*, the exchange rate elasticity decreases by 0.312, based on Column (7). The coefficient of this interaction term is significant at 5%. We further use the slope analysis for a more precise understanding of the estimated results. When the PCI is at the lowest 1 percentile (PCI=-0.55), the slope of the line includes both the main effect of the bilateral real exchange rate and the interactive effect of the bilateral real exchange rate and PCI. Thus, the overall effect on export value is estimated to be -1.263 (=-1.091+0.312*(-0.55)). When PCI is at the 25th percentile (PCI=0.61), relatively more sophisticated than those at 1st percentile, the line is estimated to be flatter, and the slope is -0.901. At the 50th percentile (PCI=1.00), the slope is -0.779; at the 75th percentile (PCI=1.56), the slope is -0.604; And at the 99th percentile (PCI=2.36), products with relative high sophistication, the slope is estimated to be

-0.355. The slope analysis indicates that the increase in PCI is associated with a decline in the overall effect on the export value. Thus, the analysis asserts that the exchange rate effect is reduced when the sophistication level of the product increases. For instance, for basic ICT products, a change in the exchange rate might have a relatively larger impact on the exports. This is because these products often compete more on price in international markets. As the products evolve to higher levels of sophistication, other factors such as technological superiority, brand value, and after-sales service become more crucial. Thus, the effect of exchange rate fluctuations, which mainly affects price competitiveness, becomes less significant. Columns (8) and (9) in Panel A provide stable results obtained using different fixed effects, despite the difference in magnitudes.

The findings regarding the tariff rate are unexpected. The coefficient of the interaction term between PCI and the tariff is negative and statistically significant at the 5% level (as shown in Column 7). This implies that as product sophistication rises (an increase in PCI*pt*), Chinese ICT product exports are affected more by tariffs. Upon conducting a slope analysis, when PCI is at the 1st percentile (PCI = - 0.55), the estimated overall effect on export value is 1.498. As product sophistication increases to the 25th percentile (PCI = 0.61), the slope becomes - 0.886. At the 50th percentile (PCI = 1.00), the slope is - 1.687. At the 75th percentile (PCI = 1.56), the slope is - 2.838, and at the 99th percentile (PCI = 2.36), the estimated slope is - 4.482. This shows that the impact of tariffs on product sophistication is harmful, which is in contrast to the results we obtained for the exchange rate.

High-end ICT products, such as advanced semiconductor chips or state-of-the-art communication equipment, usually require a complex supply chain involving components from various countries. A protectionist environment is especially disruptive in this case. Tariffs increase the cost of importing inputs, which directly affects the production cost of sophisticated products. Multinationals also prefer to produce in other countries where the finished products are not subject to tariffs. They may thus relocate production away from countries facing tariffs. In addition, the uncertainty that accompanies a protectionist environment acts as a brake on investment and production. For these reasons, tariffs are especially detrimental to advanced ICT exports. This is worrying because an increase in tariffs will lead to intensified competition on the technology frontier for China. It is to be noted though that coefficients of the interaction term in Columns (8) (9) are not significant.

Table 4. Results with sophistication levels using ln(X+1)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: *dependent variable is deflated export value in RMB-exchange rate and tariff effect*									
lnBRER*jt*	-1.023***	-1.201***	-1.153***				-1.091***	-1.265***	-1.177***
	(0.166)	(0.177)	(0.181)				(0.181)	(0.202)	(0.199)
ln*TARIFF jpt*				0.197	-2.195**	-2.939***	0.368	-0.863	-1.688**
				(0.932)	(0.968)	(0.922)	(0.887)	(0.782)	(0.629)
PCI*pt*	-0.196	-0.237		-0.168	-0.376**		-0.089	-0.205	
	(0.161)	(0.171)		(0.118)	(0.140)		(0.115)	(0.132)	
lnBRER*jt* *PCI*pt*	0.268**	0.498***	0.480***				0.312**	0.513***	0.437***
	(0.112)	(0.132)	(0.135)				(0.122)	(0.142)	(0.140)
lnTARIFF*jpt* * PCI*pt*				-1.790**	0.300	1.195*	-2.055**	-0.845	0.080
				(0.829)	(0.760)	(0.676)	(0.895)	(0.673)	(0.467)
lnY*jt*	1.136***	1.079***	1.069***	1.369***	1.344***	1.316***	1.138***	1.107***	1.087***
	(0.151)	(0.147)	(0.151)	(0.225)	(0.220)	(0.225)	(0.218)	(0.213)	(0.217)
Constant	-19.30***	-17.85***	-17.84***	-24.81***	-23.94***	-23.64***	-20.08***	-18.32***	-18.05***
	(3.757)	(3.643)	(3.733)	(5.660)	(5.534)	(5.641)	(5.529)	(5.336)	(5.444)
Fixed Effects	jp-t	j-p-t	j-pt	jp-t	j-p-t	j-pt	jp-t	j-p-t	j-pt
Observations	144,304	144,484	144,482	100,649	100,942	100,938	100,192	100,483	100,479
Adjusted R-squared	0.837	0.771	0.805	0.880	0.806	0.826	0.880	0.809	0.829
Panel B *:dependent variable is export volume-exchange rate and tariff elasticity*									
lnBRER*jt*	-1.117***	-1.045***	-0.924***				-1.331***	-1.257***	-1.069***
	(0.256)	(0.243)	(0.221)				(0.321)	(0.303)	(0.266)
ln*TARIFF jpt*				3.048**	0.196	-1.562*	3.397**	1.613*	-0.685
				(1.474)	(0.829)	(0.847)	(1.513)	(0.861)	(0.667)
PCI*pt*	-0.672**	-0.764**		-0.342	-0.638*		-0.179	-0.445	
	(0.330)	(0.350)		(0.315)	(0.325)		(0.304)	(0.320)	
lnBRER*jt* *PCI*pt*	0.470**	0.452***	0.327**				0.565**	0.508***	0.286**
	(0.182)	(0.159)	(0.130)				(0.216)	(0.181)	(0.132)
lnTARIFF*jpt* * PCI*pt*				-3.777***	-1.061	0.724	-4.197***	-2.262***	-0.048
				(1.054)	(0.703)	(0.598)	(1.145)	(0.762)	(0.448)
lnY*jt*	1.351***	1.306***	1.240***	1.773***	1.680***	1.638***	1.547***	1.464***	1.420***
	(0.241)	(0.233)	(0.246)	(0.380)	(0.365)	(0.398)	(0.389)	(0.373)	(0.405)
Constant	-23.81***	-22.60***	-21.72***	-34.56***	-31.90***	-31.49***	-29.20***	-26.85***	-26.18**
	(5.990)	(5.814)	(6.100)	(9.573)	(9.203)	(10.018)	(9.792)	(9.392)	(10.170)
Fixed Effects	jp-t	j-p-t	j-pt	jp-t	j-p-t	j-pt	jp-t	j-p-t	j-pt
Observations	97,179	97,483	97,470	66,432	66,864	66,852	66,206	66,637	66,625
Adjusted R-squared	0.566	0.524	0.652	0.609	0.559	0.671	0.610	0.561	0.673

Notes:Different paired fixed effects of Importing economy(*j*), product(*P*)and time(*t*) are included. Robust standard errors adjusted for clustering at the importing economy-level and product-level are reported in parentheses. '***','**',and'*' indicated significance at the one, five,and ten percent levels.

Panel B presents the estimations of the exchange rate elasticity and the effects of tariffs on the volume of exports. We observe a similarity in the sign of the coefficients related to the exchange rate and tariffs as in Panel A. However, the magnitudes of the impacts of both the exchange rate and tariffs are different. This difference in magnitude implies that the relationship between these factors and export volume is distinct from their relationship with other variables considered in Panel A. The findings further confirm that as products become more sophisticated, the influence of the exchange rate on export volume gradually decreases. On the other hand, the impact of tariffs is far more negative on sophisticated products. As the sophistication level increases, the higher magnitude of the interaction term results in a more negative effect of tariffs.

5.3 Robustness Tests

Some have argued that models based on log-linearized equations may result in biased estimation. Under heteroskedasticity, OLS-estimated parameters of log-linearized models yield biased elasticity estimates. Therefore, an alternative estimator based the use of the Poisson pseudo maximum likelihood (PPML) is proposed (Silva and Tenreyro, 2006). This method is considered more robust in handling the data structure and relationships, potentially reducing the bias in the estimation. In light of these recommendations, estimation using PPML in conjunction with a high-dimensional fixed effects specification is undertaken. This model incorporates importer–product–time fixed effects as before. The results are reported in Table 5 which is analogous to Table 2 above. The outcome of this estimation aligns with what was anticipated and is consistent with the previous analyses conducted. There are some changes in magnitude but the results for the baseline model remain more or less intact.

Table 5. Baseline robustness checks using ppmlhdfe (poisson high dimensional fixed effects)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: *dependent variable is deflated export value in RMB-exchange rate and tariff effect*									
lnBRER*jt*	-0.543***	-0.540***	-0.541***				-0.500***	-0.516***	-0.508***
	(0.085)	(0.086)	(0.074)				(0.071)	(0.074)	(0.122)
ln*TARIFFjpt*				-4.236***	-1.872	-2.130***	-3.777**	-1.623	-1.806*
				(1.554)	(1.149)	(0.940)	(1.469)	(1.148)	(0.980)
lnY*jt*	1.058***	1.064***	1.063***	1.070***	1.161***	1.152***	0.922***	1.003***	0.999***
	(0.276)	(0.277)	(0.335)	(0.226)	(0.245)	(0.317)	(0.217)	(0.235)	(0.317)
Constant	-12.74*	-13.06*	-12.99	-12.69***	-15.40***	-15.10*	-8.840	-11.28*	-11.11
	(7.705)	(7.751)	(9.329)	(6.310)	(6.845)	(8.864)	(6.086)	(6.605)	(8.865)
Fixed Effects	jp-t	j-p-t	j-pt	jp-t	j-p-t	j-pt	jp-t	j-p-t	j-pt
Observations	145,588	145,774	145,772	100,960	101,268	101,264	100,192	100,808	100,804
Adjusted R-squared	0.961	0.915	0.934	0.963	0.916	0.933	0.963	0.916	0.933
Panel B *:dependent variable is export volume-exchange rate and tariff elasticity*									
lnBRER*jt*	-1.977	-2.284***	-2.277***				-1.381***	-1.874***	-1.712***
	(1.602)	(0.300)	(0.613)				(0.320)	(0.716)	(0.602)
ln*TARIFFjpt*				-5.835***	-1.718	-4.452***	-3.210	0.268	-2.234**
				(2.204)	(8.940)	(0.978)	(2.106)	(3.066)	(0.976)
lnY*jt*	0.024***	-0.006	-0.013	0.500***	0.663***	0.442	0.229***	0.210***	0.053
	(0.015)	(0.182)	(0.418)	(0.001)	(0.074)	(0.452)	(0.010)	(0.018)	(0.379)
Constant	17.98***	18.24***	19.03*	6.804***	1.884***	8.606	12.97***	12.61***	17.70*
	(1.021)	(5.077)	(10.975)	(0.002)	(1.444)	(12.384)	(0.010)	(0.038)	(10.098)
Fixed Effects	jp-t	j-p-t	j-pt	jp-t	j-p-t	j-pt	jp-t	j-p-t	j-pt
Observations	97,173	97,483	97,470	66,430	66,864	66,852	66,204	66,637	66,625
Adjusted R-squared	0.865	0.809	0.92	0.883	0.811	0.928	0.886	0.816	0.932

Notes:Different paired fixed effects of Importing economy(*j*), product(*P*)and time(*t*) are included. Robust standard errors adjusted for clustering at the importing economy-level and product-level are reported in parentheses. '***','**',and'*' indicated significance at the one, five,and ten percent levels.

The PPML results presented in Table 6 are analogous to those in Table 4. In both cases, the analysis is carried out according to the sophistication levels of the products. Once more, we notice variations in the magnitudes of the coefficients of the interaction terms. However, the signs and significance levels are alike, which further validates our earlier findings. This disparity in magnitude implies that even though a different estimation approach is employed, the basic relationships among these variables remain essentially unaltered.

The findings of these robustness tests reinforce two vital conclusions. First, as products become more sophisticated, the responsiveness of exports to exchange rate fluctuations falls. Second, regarding tariffs, as the sophistication level rises, the larger magnitude of the interaction term leads to a more substantial negative impact of tariffs. These consistent results enhance the credibility of our overall conclusions concerning the relationships between exchange rates, tariff rates, product sophistication, and China's exports.

Table 6. Sophistication robustness checks using ppmlhdfe (poisson high dimensional fixed effects)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: *dependent variable is deflated export value in RMB-exchange rate and tariff effect*									
lnBRER*jt*	-0.981***	-0.883***	-0.745***				-0.960***	-0.887***	-0.696***
	(0.161)	(0.145)	(0.130)				(0.164)	(0.121)	(0.110)
ln*TARIFF jpt*				-2.372	-0.974	-2.368**	-0.767	0.971	-0.990
				(1.773)	(1.008)	(1.094)	(2.029)	(1.067)	(0.918)
PCI*pt*	0.086	0.013		-0.233	-0.256		0.185	0.086	
	(0.161)	(0.242)		(0.241)	(0.244)		(0.220)	(0.212)	
lnBRER*jt* *PCI*pt*	0.637***	0.490**	0.307**				0.654***	0.510**	0.262**
	(0.223)	(0.215)	(0.149)				(0.241)	(0.201)	(0.114)
lnTARIFF*jpt* * PCI*pt*				-3.181	-1.758	0.539	-4.804**	-3.886***	-0.914
				(2.057)	(1.410)	(1.339)	(2.295)	(1.426)	(0.973)
lnY*jt*	1.012***	0.987***	1.000***	1.086***	1.162***	1.151***	0.881***	1.000***	0.958***
	(0.266)	(0.277)	(0.324)	(0.233)	(0.260)	(0.317)	(0.217)	(0.324)	(0.313)
Constant	-11.51	-10.95	-11.21	-12.96**	-15.23**	-15.08*	-7.816	-9.472	-9.969
	(7.490)	(7.811)	(9.023)	(6.606)	(7.377)	(8.849)	(6.197)	(6.963)	(8.746)
Fixed Effects	jp-t	j-p-t	j-pt	jp-t	j-p-t	j-pt	jp-t	j-p-t	j-pt
Observations	145,588	145,774	145,772	100,960	101,268	101,264	100,502	100,808	100,804
Adjusted R-squared	0.962	0.917	0.934	0.963	0.916	0.934	0.965	0.933	0.933
Panel B *:dependent variable is export volume-exchange rate and tariff elasticity*									
lnBRER*jt*	-2.268***	-2.504***	-2.398***				-1.741***	-2.100***	-1.795***
	(0.187)	(0.359)	(0.589)				(0.301)	(0.308)	(0.594)
ln*TARIFF jpt*				-6.911***	-3.398	-6.462***	-2.453	0.608	-2.666**
				(1.868)	(2.097)	(1.928)	(2.106)	(2.148)	(1.237)
PCI*pt*	-1.441***	-1.660**		-2.145***	-2.350***		-1.254***	-1.635***	
	(0.356)	(0.402)		(0.353)	(0.371)		(0.479)	(0.458)	
lnBRER*jt* *PCI*pt*	1.189***	0.962**	0.672**				1.105***	0.853*	0.479**
	(0.362)	(0.383)	(0.284)				(0.424)	(0.448)	(0.241)
lnTARIFF*jpt* * PCI*pt*				4.431***	4.893***	6.480**	0.798	0.570	3.024**
				(2.033)	(1.872)	(2.829)	(1.914)	(1.641)	(1.466)
lnY*jt*	-0.244	-0.570	-0.481***	0.674***	0.582*	0.345	0.120***	-0.216	-0.216
	(0.269)	(0.520)	(0.520)	(0.241)	(0.338)	(0.467)	(0.013)	(0.391)	(0.462)
Constant	25.82***	34.21***	31.73***	2.846	5.024	11.27	16.32***	24.91**	25.09**
	(7.461)	(13.876)	(13.830)	(6.533)	(9.175)	(12.804)	(0.005)	(10.689)	(12.437)
Fixed Effects	jp-t	j-p-t	j-pt	jp-t	j-p-t	j-pt	jp-t	j-p-t	j-pt
Observations	97,173	97,483	97,470	66,430	66,864	66,852	66,204	66,637	66,625
Adjusted R-squared	0.896	0.845	0.922	0.906	0.842	0.930	0.911	0.850	0.934

Notes:Different paired fixed effects of Importing economy*(j),* product(*P*)and time(*t*) are included. Robust standard errors adjusted for clustering at the importing economy-level and product-level are reported in parentheses. '***','**',and'*' indicated significance at the one, five,and ten percent levels.

5.4 Product-wise Estimation of Exchange Rate and Tariff Effects

Subsequently, we estimated the exchange rate effect and tariff effect for 44 ICT products separately. We selected 15 of the most important ICT products among them. These products were either ranked among the top 10 in the telecommunications sector when considering the proportion of each product in China's total exports, or stood out in terms of the ratio of China's exports in that particular category to the global exports in the same category[15]. Results of these 15 selected important ICT products are listed in Table 7[16]. We summarized the exchange rate effect, tariff effect, income effect, sophistication level, average PCI, the export share of China's export basket, and export share of the world export basket in the table. The results in Table 7 are sorted by average PCI, from products with low-level sophistication (4) to products with high-level sophistication (1). As shown in the table, most of these products are assigned sophistication levels 1 or 2, indicating the high-technology requirements of ICT products. Our theoretical analysis suggests that individual products with lower sophistication levels should have greater exchange rate responses, compared with the products characterized by high-level sophistication. Most results follow our expectations. We also offer a detailed analysis of some typical goods with exchange rate effects that can not only be explained by sophistication levels and do not follow our expectations regarding sophistication levels.

For example, magnetic tape recorders, which are products with medium-level sophistication, should not exhibit a large exchange rate effect. However, the coefficient is significant at 1% and is equal to -3.078. This result indicates that when yuan appreciates by 10%, the deflated export value decreases by 30.8%. This large exchange rate effect might be caused by the specific product feature of magnetic tape recorders. Magnetic tape recorders are “old fashioned” products because wireless networks became common in the 2000s, whereas magnetic tapes are now rarely used to record things. Therefore, this occurrence could lead to a large exchange rate effect for this particular product. China has competitive powers over products in the telephone industry. Such products exert nonsignificant exchange rate effects for parts of radios of telephones and TV; telephones; and transmission devices for radio, telephone, and TV. The possible reasons are as follows: First, these products are sophisticated in nature. Second, these products are super competitive in the world market since the ecosystem for producing telephones and related products has been well established in China, and this ecosystem promotes the competitiveness of China in these related industries. To explain this ecosystem in detail, we use the telephone ecosystem in Shenzhen as example. Many companies located in Shenzhen, Shanghai, and Beijing offer services, including (i) Original Equipment Manufacturers whose production business is outsourced by

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[15] We use average share from 2003 to 2018 to figure out the top 10 ICT products that the export share of China's total exports or China's exports in this category relative to world exports in the same category.

[16] Results of all 44 ICT products are available upon request.

the original brand, (ii) Original Design Manufacturers whose design and production business is outsourced by the original brand, and Independent Design Houses (IDHs), which bridge the ICT original company and the machine enterprise, as well as integrate upstream with downstream in the industrial chain. These IDHs build and develop platforms, suggest solutions, as well as create foundations for product R&D for different baseband and chipset suppliers.[17] Therefore, any problems and issues related to the manufacture of phones can be easily solved in Shenzhen (Wang, 2021). Third, the huge market in China and picky customers promote innovation in the telephone industry, productivity in the production process, and problem-solving efficiency on the customer service side. All these features may render the exchange rate effects nonsignificant for these products.

The exchange rate effects for electrical transformers and computers are relatively high at -0.798 and -0.496 and significant at 1%. For these highly sophisticated products, the exchange rate effects remain relatively high. The reason may be that these industries face many competitions from other exporters, particularly other East Asian economies such as Japan, South Korea, and Taiwan. China became a key player in the supply of these products only after mid-2000s and thus could not be a leader in these industries. For example, China's share in the global exports of semiconductors to the U.S. remains small, and most exports of semiconductors to the U.S. are dominated by other Asian economies.[18] For more advanced and smaller nm-sized semiconductors, China still lacks technology support in production, and the R&D needs to be improved. Similarly, the electronic integrated circuits exports only comprise 8.51% of the world market, on average.

When we turn our attention to the impact of tariffs, it becomes evident that highly sophisticated products are disproportionately affected. Take semiconductor devices as a prime example, which are highly sophisticated, and has high coefficient of - 11.096 and significant at 1%. This coefficient value implies that for every 1% increase in the tariff rate imposed on semiconductor devices, the volume of Chinese exports of these products drops by 11%. This significant decline in exports due to tariff hikes clearly demonstrates the sensitivity of such high-tech products to trade-related barriers. Other products with high-value coefficients include parts of radios, telephones, and TVs, with a coefficient of - 10.214.

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[17] The detailed explanation can be found at https://www.neway.mobi/idh-company-index/

[18] Refer to Bown (2020) for the detailed analysis of the U.S. import of semiconductors by source, where the author provides the data dating back to 1980 to most recent time.

Computers have a coefficient of - 7.953, and telephones have a coefficient of - 6.629. These figures suggest that China's export performance for these highly sophisticated products is severely hampered by tariff increases. This overall situation highlights China's vulnerability in the international market when it comes to highly sophisticated products. China is currently grappling with various technological challenges on the global stage. Other economies are attempting to take advantage of these situations. For instance, they might impose higher tariffs precisely because they know that China's high-tech exports are crucial but also sensitive to such trade measures. This could be a strategic move to gain a competitive edge in the global technology-driven markets.

Transmission apparatus, despite being a highly sophisticated product, has a relatively low coefficient of - 3.201. One possible reason for this is the highly competitive nature of the market segment for transmission apparatus. There are numerous suppliers operating in this space. As a result, when a tariff is imposed, Chinese exporters of transmission apparatuses may face less of a negative impact because they can potentially shift their business strategies more easily. They could, for example, find alternative sources for components, target different markets, or engage in price-competition more effectively compared to products with fewer suppliers. This variance in the tariff-sensitivity of different highly sophisticated products showcases the complexity of the global trade dynamics for high-tech goods.

Table 7. Exchange rate effect, tariff effect and income effect for important products

HS4-digit	Product name	Exchange Rate Effect	S.E.	Tariff Effect	S.E.	Sophistication Level	Average PCI	Export share of China's export basket	Export share of world export basket
8544	Insulated electrical wire	-0.926***	0.141	-3.900***	1.111	4	-0.435	0.86%	16.74%
8470	Cash registers, calculators,etc	-1.343***	0.236	-6.421***	1.248	3	-0.036	0.11%	37.20%
8518	microphones	-1.140***	0.340	-4.302***	1.206	3	0.066	0.72%	44.07%
8527	Reception apparatus for radio broadcasting	-1.708***	0.32	-4.233***	1.601	3	0.102	0.46%	34.32%
8520	Magnetic tape recorders	-3.078***	0.546	-0.624	1.795	3	0.297	0.11%	35.58%
8534	Electronic printed circuits	0.111	0.243	-6.186***	1.616	2	0.430	0.69%	32.41%
8504	Electrical transformers	-0.798***	0.177	-5.779***	1.109	2	0.441	1.27%	28.92%
8541	Semiconductor devices	-0.677	0.670	-11.096***	4.216	2	0.548	1.11%	21.75%
8542	Electronic integrated circuits	0.646*	0.343	4.480*	2.688	2	0.641	2.31%	8.51%
8529	Parts of radios, telephones, and T.V.s	-1.046***	0.228	-10.214**	4.450	2	0.678	1.14%	28.36%
8473	Parts and accessories for office machines	-0.490	0.377	-4.298	4.704	2	0.686	2.81%	28.80%
8471	Computers	-0.496***	0.092	-7.953***	1.766	2	0.721	8.01%	42.60%
8517	Telephones	-0.481***	0.172	-6.629***	2.152	2	0.833	3.05%	32%
8525	Transmission apparatus for radio,telephone and TV	-0.004	0.188	-3.201*	1.928	2	0.838	4.91%	39.16%
8472	Other office machines	-0.661***	0.216	-9.375***	3.454	1	1.495	0.13%	30.43%

Notes: Fixed effects of importing economy and product paired (*jp*) and time(*t*) are implemented. Robust standard errors adjusted for clustering at the importing economy-level are reported in S.E.. '***','**', and '*' indicated significance at the one,five and ten percent levels. Sophistication levels are as per author's classification. "1" represents high sophisticated products, "2" represents medium high sophisticated products,"3" represents medium sophisticated products, "4" represents medium low sophisticated products and "5" represents low sophisticated products. Export shares of China's export basket and world export basket are calculated by authors.

6. Analysis of the Telecommunications Industry in China

In this section, we provide an in-depth analysis of the ICT industry using product space theory (Hidalgo et.al., 2007) to understand the behavior of exchange rate effects for important ICT products. We first briefly introduce the overall development and innovation path of the telecommunications industry in China. Table 8 summarizes the sophistication levels of 44 ICT products in Attachment A of the ITA, with many ICT products categorized under sophistication levels 1 and 2. Thus, most ICT products are highly sophisticated products requiring complex capabilities for production.

Table 8. ICT products sophistication level and PCI summary

HS-4-digit	Product Name	Sophistication level	Average PCI	HS-4-digit	Product Name	Sophistication level	Average PCI
3818	Chemical elements for electronics	1	1.602	8524	Tapes, cassettes, records and compact disks	1	1.460
7017	Laboratory,hygienic or pharmaceutical glassware	1	1.527	8525	Transmission apparatus for radio, telephone and TV	2	0.838
8419	Equipment for temperature change of materials	1	1.557	8527	Reception apparatus for radio broadcasting	3	0.102
8421	Centrifuges	1	1.342	8529	Parts of radios, telephones, and T.V.s	2	0.678
8424	Sprays and powder dispersers	1	1.198	8531	Electric sound or visual signaling apparatus	2	0.696
8456	Machines for working materials by laser and similar means	1	1.834	8532	Electrical capacitors	2	0.600
8464	Machine tools for working stone	1	1.387	8533	Electrical resistors	2	0.645
8466	Parts and accessories for metal working machines	1	1.481	8534	Electronic printed circuits	2	0.430
8469	Word processing machines	3	-0.073	8536	Electrical apparatus for <1k volts	2	0.664
8470	Cash registers, calculators,etc	3	-0.036	8541	Semiconductor devices	2	0.548
8471	Computers	2	0.721	8542	Electronic integrated circuits	2	0.641
8472	Other office machines	1	1.495	8543	Electrical machines with individual	1	1.087
8473	Parts and accessories for office machines	2	0.686	8544	Insulated electrical wire	4	-0.435
8477	Machinery for working rubber or plastics	1	1.684	9009	Electrostatic photo-copyers	2	0.505
8479	Machines n.e.c	1	2.137	9010	Apparatus and equipment for photographic	1	1.747
8480	Molding boxes for metal foundry	1	1.245	9011	Optical microscopes	1	1.204
8504	Electrical transformers	2	0.441	9012	Microscopes, other than optical	1	1.891
8514	Industrial electric furnaces	1	1.647	9017	Drafting tables and machines	1	1.247
8517	Telephones	2	0.833	9026	Instruments for measuring properties of	1	1.592
8518	Microphones	3	0.066	9027	Instruments for physical or chemical	1	1.914
8520	Magnetic tape recorders	3	0.297	9030	Instruments for measuring electricity	1	1.505
8523	Sound storage media	1	0.419	9031	Measuring instruments	1	1.586

In Table 8 we see how product complexity varies across the supply chain. Capital goods such as machines n.e.c., machines for working materials by laser, machinery for working rubber or plastics, and equipment for temperature change of materials have the highest PCI values. These goods are often made in advanced countries using specialized technologies. Final electronics goods such as computers and telephones have lower PCI values than the capital goods. Final goods are assembled using inputs produced by various companies, and the act of assembling the inputs is less advanced than manufacturing capital goods. Parts such as electrical resistors, electrical capacitors, and electrical transformers have lower PCI values than the final electronics goods. These are often produced by less sophisticated companies within the supply chains.

We use the concept of the product space (Hidalgo and Hausmann, 2009) to probe into the development of the ICT industry in China. The product space diagram shows the universe of all products being traded globally. Each bubble represents a specific export product with revealed comparative advantage (RCA >=1), and the size of the bubble denotes the world share of the product in each economy in that year. The bubbles with different colors represent different industries. The telecommunications industry is denoted by a blue color. If a certain product is not exported with RCA in the economy, that product appears white. Generally, similar products would be clustered with each other. Therefore, the closeness between the bubbles indicates the proximity of the products in terms of the required capabilities to produce these products. The idea of the product space is that the countries can accumulate appropriate capabilities to jump from one industry to a nearby industry in the process of diversifying its production process over the years.[19]

The telecommunications industry was not adequately developed and reformed before the 2000s as China had no sufficient capabilities to manufacture ICT products. Figure 2 shows the product space of China in the 1990s. Footwear, children's toys, and textiles have been important exports since 1990, as indicated by the green bubbles (towards the right) in Figure 2. These items were core exports in China, as indicated by a product space diagram at the time. ICT products are indicated in blue bubbles within the green circle (towards the left of the figure). China did not produce much of the core telecommunication products, such as computers (HS-8471), electronic integrated circuits (HS-8542), and semiconductor devices (HS-8541). As shown in the green circle of the product space, the two largest bubbles are computers (labeled 2) and electronic integrated circuits (labeled 1), and all semiconductor devices (labeled 3 in Figure 2) are white. The telephone (labeled 4) has an RCA, but the export amount is still emerging and not influential in the world market. However, with the development of the telecommunications industry, particularly after joining the WTO and participating the ITA, the product space of China in the ICT industry begins to change noticeably.

Figures 3 and 4 present China's product space for 2003 and 2012, respectively. The evolution of more colored bubbles in telecommunications became more pronounced; by 2012, electronic integrated circuits appeared in blue color. Figure 5 shows the product space for 2018, the most recent year in our sample period. On the basis of the product space analysis, China has acquired capabilities and progressed to export these sophisticated products. China has become the world-leading exporter of ICT products. After the late 2000s, Chinese telecom multinationals, such as Huawei and ZTE, have become global competitors alongside Ericsson, Alcatel-Lucent, and Nokia Simens Networks. China's telecom multinational Datang has become a global key technological provider of 3G standard TD-

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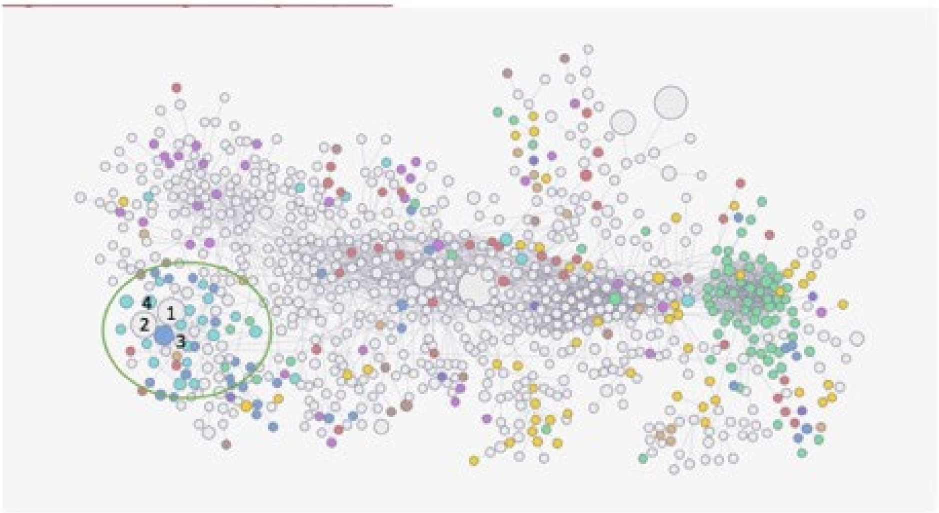
[19] Please see Chen, Salike, and Thorbecke (2020) for detailed interpretations, along with a discussion on China's evolution and development of the product space.

SCDMA and 4G-related products TD-LTE (Zhou, Lazonick &Sun, 2016). Thus, the innovation and development path of telecommunications in China deserves further investigation.

Figure 2: China's product space (1995)



Source: Atlas of Economic Complexity (http://atlas.cid.harvard.edu/)

Figure 3: China's product space (2003)

Source: Atlas of Economic Complexity (http://atlas.cid.harvard.edu/)

Figure 4: China's product space (2012)

Source: Atlas of Economic Complexity (http://atlas.cid.harvard.edu/)

Figure 5: China's product space (2018)

Source: Atlas of Economic Complexity (http://atlas.cid.harvard.edu/)

The development path of telecommunications in East Asia follows the flying geese model.[20] Japan has been the leading exporter of telecommunications products since 1980s; South Korea, Taiwan, and Singapore followed in the 1990s. China joined the WTO late, and the telecommunication industry prospered after 2001.

This finding can also be substantiated by recalling the history of trade disputes in the semiconductor industry between the U.S. and other East Asian countries. The U.S. first had intensive trade disputes with Japan in the 1980s to reduce severe competition from Japanese semiconductor producers; South Korea and Taiwan then became competitors in the 1990s and 2000s; currently, this dispute is with China (Bown, 2020).

As a latecomer in telecommunications, China needs to catch up and advance technologically. Research on catching up and technological upgrading strategies for latecomers (a series of theories summarized by Zhou, Lazonick & Sun, 2016) indicates that catching-up countries follow a process from imitation to innovation. They start by acquiring and learning the technology from advanced economies and mostly from the spillover effects of FDI technology. If successful, latecomers might accumulate domestic-related capabilities to innovate for higher-quality and lower-cost products, compared with other global competitors. China has been successful in achieving this goal and has become a global leader by focusing on infrastructure building, developing the internal technology development of innovative firms (Zhou, Lazonick & Sun, 2016), and liberalizing reforms in trade and FDI policies, together with ambitious technological upgrading strategies (Huang, Salike & Zhong, 2017).

Chinese telecommunication infrastructure has markedly improved since 2000, and mobile cellular subscriptions have subsequently skyrocketed (Zhou, Lazonick &Sun, 2016). In 2012, China surpassed the U.S. to lead the world in mobile phone and internet use. These demand and infrastructure constructions build solid foundations for the development of telecommunications. Since 2000, the Chinese government replaced direct financial aid with dynamic and selective financial support for domestic firms focused on the development of cutting-edge technologies and standards in mobile and data communications. The government also mediated the domestic demand conditions for leading companies by creating direct linkages between the market and domestic suppliers—for instance, encouraging state-owned enterprises to prioritize the purchase agreement with domestic leading corporations

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[20] The term flying geese model was coined by Akamatsu (1962) to explain the development pattern of industries in East Asia, where the first goose takes the lead and others follow the lead goose.

such as Huawei (ibid, 2016). Apart from emphasizing technology transfer via joint ventures adopted by other domestic firms, leading enterprises such as Huawei, ZTE, and Datang emphasize internal development more although this motivation for internal development has been impeded by internal and external obstacles. These include insufficient money to import key components, trade barriers, and technology restrictions from advanced countries. The aforementioned difficulties strengthened the determination of firms and government support in developing proprietary technology (ibid, 2016). Wang (2021) reports that Huawei tries every possible means to apply its R&D in more efficient ways, such as hiring a super pioneer in technology innovation instead of forming a large team to innovate. Employees at Huawei have cultivated a certain corporate culture that views pursuing technological innovation and seeking the best and most efficient solutions for customers as their own highest goods. In 2018, Huawei submitted 5,405 intellectual property (IP) applications to the World Intellectual Property Organization (WIPO), which ranked first in global MNCs. Huawei has acquired 87,805 IP rights up to 2018 (ibid, 2021). China's large and thick domestic markets also motivate internal innovation in these leading companies as they are more aware of the customers' needs and usage problems of their devices in actual practice than foreign MNCs. All aforementioned reasons lead to considerable development in telecommunications after China's WTO accession and ITA participation.

As estimated in the benchmark model described in Section 6.1, the exchange rate effect for the overall telecommunications industry in China is -0.486. Thus, when the yuan appreciates by 10%, the export value of all ICT products decreases by 4.86%. In our earlier research related to the exchange rate effect and product sophistication levels, we reported the exchange effect is -0.67 for 960 HS 4-digit manufacturing products in China (Thorbecke, Chen & Salike, 2021). On the basis of our hypothesis that sophisticated products react less to changes in exchange rate, these results are as expected when considering information on the average sophistication levels of ICT products, which are relatively high, as indicated in Table 5.

Some might argue that although China has become the leading exporter of ICT products, the value added in ICT exports remains low because China only assembles the products in its trade processing zones. However, the OECD's trade-in-value-added (TIVA) data show that Chinese enterprises added more than 55% of the value added in ICT exports in

2009[21] (Ezell and Atkinson, 2014). With technological advances and innovations in telecommunications industries, China has become the leading economy in smartphones, 4G, and 5G, among others. It has successfully achieved transformation from imitation to innovation.

7. Conclusion and Policy Implications

This paper delves into the telecommunications industry in China over the 2003 to 2018 period. The aim is to gain a comprehensive understanding of this industry, which has been particularly prone to trade frictions. By exploring the industry over this specific time frame, the paper seeks to paint a clear picture of the various aspects and challenges it has faced in the context of trade-related tensions. We conduct a thorough empirical analysis to explore the impacts of exchange rates and their elasticities, as well as the effects of tariffs, on the exports of ICT products. These analyses are conducted from the perspective of different sophistication levels of products. We also introduce the Information Technology Agreement (ITA), which has had a profound impact on the global trade of ICT products.

We employ bilateral exports of 44 ICT products, classified at the HS 4-digit level with 196 partner economies for the period 2003–2018. The sophistication level of a product is derived using the PCI as advocated by Hidalgo and Hausmann (2009). We employ the fixed-effects regression suggested by Bénassy-Quéré et al. (2021) using various combinations of importer–product–time fixed effects. We find that both exchange rate appreciations and tariff rate increases have negative impacts on the exports of ICT products. However, their impact on products with different sophistication levels is heterogenous. We find that the sensitivity of the export value to exchange rates decreases as products become more sophisticated. Exchange rate changes influence China's highly sophisticated ICT exports less. This result is consistent with previous studies. On the other hand, the effect of tariffs is found to be much higher for the sophisticated products.

China's emergence as an exporting powerhouse of ICT products has garnered significant attention. This study makes two contributions. On the exchange rate front, China's exchange rate always generates concerns. With the implementation of tariff-reducing agreements like the ITA, exchange rate effects become even more important for analyzing the exports of this important industry. Given that China is facing pressure to appreciate its

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[21] OECD/WTO Trade in Value Added Indicators: China.

currency, the associated risks for its manufacturers are a serious concern. Our conclusion indicates that the export value of ICT products is limitedly affected by changes in exchange rate owing to its limited magnitude. The exchange rate effect tends to be less for more sophisticated ICT products. However, other possible reasons might also influence the exchange rate effect. Changes in export volume caused by fluctuations in the real exchange rate are not affected by sophistication levels. This finding leads to significant research potential for further studies, specifically regarding the features of each ICT product and exchange-rate pass-through analysis.

The result of tariff effects is unexpected. This result clearly demonstrates that tariffs have a deleterious effect on product sophistication. Product sophistication often involves the integration of advanced technologies, high-quality components, and innovative design elements. When tariffs are imposed, the cost of importing key components and raw materials necessary for producing sophisticated ICT products increases. This rise in costs can impede the R&D and production processes that drive product sophistication. For example, high-end semiconductor components from abroad, which are crucial for the production of advanced ICT devices like high-performance smartphones or data-center servers, may become prohibitively expensive due to tariffs. As a result, Chinese ICT manufacturers may be forced to cut corners in their production or delay the introduction of more sophisticated products to the market.

Based on these differences, we can infer that tariffs are more detrimental to Chinese ICT exports than the exchange rate. Tariffs directly target the products themselves and disrupt the production and supply chains in a more fundamental way. Higher tariffs not only reduce the competitiveness of Chinese ICT products in terms of price but also limit the ability of manufacturers to produce high - quality, sophisticated products.

This situation is especially worrying because an increase in tariffs will lead to intensified competition on the technology frontier for China. In the global ICT industry, the technology frontier represents the cutting - edge of technological innovation. When tariffs are raised, Chinese ICT companies face greater challenges in accessing the latest foreign technologies and components, which are often essential for staying at the forefront of the technology race. Competitors from countries with more favorable trade policies can then gain an edge in developing and commercializing advanced ICT products. This can slow down China's progress in areas such as 5G technology deployment, artificial intelligence - driven ICT applications, and the development of next - generation data storage and processing technologies.

Finally, we present the development pattern and industrial strategy in the telecommunications sector. This includes analyzing the trends in technology adoption, market expansion, and competition within the industry. We explore how China's telecommunications industry has evolved over time, from its early stages of development to its current position as a major player in the global market. By understanding these aspects, we can provide valuable insights for policymakers, industry practitioners, and researchers interested in the future of China's ICT and telecommunications industries. The telecommunications industry is highly sophisticated in general. The magnitude of the exchange rate effect is generally limited relative to that of other less sophisticated products. Thus, the innovation and development of the industry reduce the vulnerability of manufacturers to exchange rate fluctuations. As a latecomer in the telecommunications industry, China has been attempting to catch up on the innovation path from imitation to innovation at a relatively quick speed. Its development strategy in the telecommunications industry has been successful. The importance of this industry regarding the overall sophistication feature and China’s success in this industry before 2018 raise even more concerns regarding international relations, especially with the U.S. Considering the severe trade friction and the possible “decoupling” with the U.S and other U.S.-favored economies, the future sustainable development of this industry should be of the highest importance for future study and research.

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Appendix 1: Lists of 44 ICT Products and its share

HS 4-digit	Product name	Share of World's export	Share of China's export
3818	Chemical elements for electronics	14.39%	0.08%
7017	Laboratory, hygienic or pharmaceutical glassware	7.77%	0.003%
8419	Equipment for temperature change of materials	8.06%	0.14%
8421	Centrifuges	7.17%	0.18%
8424	Sprays and powder dispersers	15.20%	0.13%
8456	Machines for working materials by laser and similar means	4.80%	0.02%
8464	Machine tools for working stone	12.36%	0.02%
8466	Parts and accessories for metal working machines	5.72%	0.05%
8469	Word processing machines	21.50%	0.001%
8470	Cash registers, calculators, etc.	37.20%	0.11%
8471	Computers	42.60%	8.01%
8472	Other office machines	30.43%	0.13%
8473	Parts and accessories for office machines	28.80%	2.81%
8477	Machinery for working rubber or plastics	10.02%	0.12%
8479	Machines n.e.c.	4.76%	0.22%
8480	Molding boxes for metal foundry	16.49%	0.14%
8504	Electrical transformers	28.92%	1.27%
8514	Industrial electric furnaces	7.50%	0.02%
8517	Telephones	32%	3.05%
8518	Microphones	44.07%	0.72%
8520	Magnetic tape recorders	35.58%	0.11%
8523	Sound storage media	17.85%	0.30%
8524	Tapes, cassettes, records and compact disks	3.56%	0.04%
8525	Transmission apparatus for radio, telephone and TV	39.16%	4.91%
8527	Reception apparatus for radio broadcasting	34.32%	0.46%
8529	Parts of radios, telephones, and T.V.s	28.36%	1.14%
8531	Electric sound or visual signaling apparatus	22.32%	0.28%
8532	Electrical capacitors	15.70%	0.20%
8533	Electrical resistors	16.33%	0.08%
8534	Electronic printed circuits	32.41%	0.69%
8536	Electrical apparatus for < 1k volts	14.57%	0.66%
8541	Semiconductor devices	21.75%	1.11%
8542	Electronic integrated circuits	8.51%	2.31%
8543	Electrical machines with individual functions n.e.c.	22.54%	0.44%
8544	Insulated electrical wire	16.74%	0.86%
9009	Electrostatic photo-copyers	20.49%	0.12%
9010	Apparatus and equipment for photographic laboratories, n.e.c.	3.26%	0.01%

9011	Optical microscopes	9.48%	0.02%
9012	Microscopes, other than optical	1.18%	0.01%
9017	Drafting tables and machines	26.60%	0.04%
9026	Instruments for measuring properties of liquids or gases	6.02%	0.05%
9027	Instruments for physical or chemical analysis	4.26%	0.08%
9030	Instruments for measuring electricity	6.32%	0.07%
9031	Measuring instruments	5.19%	0.09%

Appendix 2: List of trading partners and frequency of associated observations

	Country Name	Country Code	Frequency		Country Name	Country Code	Frequency
1	Aruba	ABW	343	51	Ecuador	ECU	961
2	Afghanistan	AFG	581	52	Egypt	EGY	1,007
3	Angola	AGO	736	53	Eritrea	ERI	398
4	Albania	ALB	798	54	Western Sahara	ESH	19
5	United Arab Emirates	ARE	1,006	55	Spain	ESP	1,041
6	Argentina	ARG	1,014	56	Estonia	EST	875
7	Armenia	ARM	663	57	Ethiopia	ETH	938
8	Antigua and Barbuda	ATG	310	58	Finland	FIN	1,024
9	Australia	AUS	1,040	59	Fiji	FJI	758
10	Austria	AUT	1,042	60	France	FRA	1,044
11	Azerbaijan	AZE	737	61	Micronesia	FSM	252
12	Burundi	BDI	512	62	Garbon	GAB	721
13	Belgium	BEL	1,042	63	United Kingdom	GBR	1,044
14	Benin	BEN	757	64	Georgia	GEO	689
15	Burkina Faso	BFA	588	65	Ghana	GHA	935
16	Bangladesh	BGD	987	66	Guinea	GIN	713
17	Bulgaria	BGR	944	67	Gambia	GMB	462
18	Bahrain	BHR	783	68	Guinea-Bissau	GNB	308
19	Bahamas	BHS	402	69	Equatorial Guinea	GNQ	531
20	Bosnia and Herzegovina	BIH	640	70	Greece	GRC	983
21	Belarus	BLR	881	71	Grenada	GRD	247
22	Belize	BLZ	474	72	Guatemala	GTM	875
23	Bermuda	BMU	163	73	Guyana	GUY	715
24	Bolivia	BOL	929	74	Hongkong	HKG	1,048
25	Brazil	BRA	1,025	75	Honduras	HND	832
26	Barbados	BRB	468	76	Croatia	HRV	925
27	Brunei Darussalam	BRN	681	77	Haiti	HTI	510
28	Bhutan	BTN	210	78	Hungary	HUN	995
29	Botswana	BWA	662	79	Indonesia	IDN	1,041
30	Central African Republic	CAF	368	80	India	IND	1,045
31	Canada	CAN	1,043	81	Ireland	IRL	1,010
32	Switzerland	CHE	1,042	82	Iran	IRN	977
33	Chile	CHL	1,010	83	Iraq	IRQ	683
34	Cote d'lvoire	CIV	928	84	Iceland	ISL	646
35	Cameroon	CMR	876	85	Israel	ISR	1,023
36	Democratic Republic of the Congo	COD	23	86	Italy	ITA	1,043
37	Congo	COG	685	87	Jamaica	JAM	808

38	Colombia	COL	1,008	88	Jordan	JOR	956
39	Comoros	COM	308	89	Japan	JPN	1,043
40	Cabo Verde	CPV	438	90	Kazakhsan	KAZ	930
41	Costa Rica	CRI	954	91	Kenya	KEN	934
42	Cuba	CUB	895	92	Kyrgystan	KGZ	780
43	Cyprus	CYP	954	93	Cambodia	KHM	867
44	Czech Republic	CZE	1,013	94	Kiribati	KIR	199
45	Germany	DEU	1,044	95	Saint Kitts and Nevis	KNA	189
46	Djibouti	DJI	680	96	South Korea	KOR	1,043
47	Dominica	DMA	627	97	Kosovo	KSV	23
48	Denmark	DNK	1,036	98	Kuwait	KWT	866
49	Dominican Republic	DOM	830	99	Laos	LAO	757
50	Algeria	DZA	995	100	Lebanon	LBN	971

	Country Name	Country Code	Frequency		Country Name	Country Code	Frequency
101	Liberia	LBR	534	151	Russian Federation	RUS	1,040
102	Libya	LBY	734	152	Rwanda	RWA	658
103	Saint Lucia	LCA	365	153	Saudi Arabia	SAU	1,012
104	Sri Lanka	LKA	977	154	Serbia and Montenegro	SCG	23
105	Lesotho	LSO	340	155	Sudan	SDN	919
106	Lithuania	LTU	873	156	Senegal	SEN	853
107	Luxembourg	LUX	728	157	Singapore	SGP	1,044
108	Latvia	LVA	829	158	Solomon Islands	SLB	480
109	Macao	MAC	989	159	Sierra Leone	SLE	574
110	Morocco	MAR	966	160	EI Salvador	SLV	835
111	Moldova	MDA	741	161	Somalia	SOM	365
112	Madagascar	MDG	932	162	Serbia	SRB	23
113	Maldives	MDV	640	163	Sao Tome and Principe	STP	180
114	Mexico	MEX	1,043	164	Suriname	SUR	664
115	Marshall Islands	MHL	241	165	Slovakia	SVK	979
116	Macedonia	MKD	814	166	Slovenia	SVN	981
117	Mali	MLI	727	167	Sweden	SWE	1,034
118	Malta	MLT	793	168	Swaziland	SWZ	322
119	Myanmar	MMR	932	169	Seychelles	SYC	439
120	Montenegro	MNE	23	170	Syrian Arab Republic	SYR	933

121	Mongolia	MNG	901	171	Turks and Caicos Islands	TCD	454
122	Mozambique	MOZ	769	172	Togo	TGO	698
123	Mauritania	MRT	550	173	Thailand	THA	1,040
124	Mauritius	MUS	952	174	Tajikistan	TJK	556
125	Malawi	MWI	692	175	Turkmenistan	TKM	585
126	Malaysia	MYS	1,045	176	Tonga	TON	401
127	Namibia	NAM	656	177	Trinidad and Tobago	TTO	882
128	New Caledonia	NCL	509	178	Tunisia	TUN	975
129	Niger	NER	647	179	Turkey	TUR	1,023
130	Nigeria	NGA	982	180	Tuvalu	TUV	73
131	Nicaragua	NIC	821	181	Taiwan	TWN	1,045
132	Netherlands	NLD	1,042	182	Tanzania	TZA	896
133	Norway	NOR	1,025	183	Uganda	UGA	806
134	Nepal	NPL	853	184	Ukraine	UKR	982
135	New Zealand	NZL	1,013	185	Uruguay	URY	967
136	Oman	OMN	823	186	United States America	USA	1,044
137	Pakistan	PAK	1,014	187	Uzbekistan	UZB	710
138	Panama	PAN	910	188	Saint Vincent and the Grenadines	VCT	224
139	Peru	PER	1,002	189	Venezuela	VEN	950
140	Philippines	PHL	1,056	190	Vietnam	VNM	1,011
141	Palau	PLW	182	191	Vanuatu	VUT	427
142	Papua New Guinea	PNG	751	192	Samoa	WSM	469
143	Poland	POL	1,005	193	Yemen	YEM	878
144	North Korea	PRK	944	194	South Africa	ZAF	66
145	Portugal	PRT	987	195	Zambia	ZMB	834
146	Paraguay	PRY	896	196	Zimbabwe	ZWE	833
147	Palestinian Territory	PSE	23				
148	French Polynesia	PYF	439				
149	Qatar	QAT	827				
150	Romania	ROU	983				