Information Economics and Policy 57 (2021) 100940

Contents lists available at ScienceDirect

Information Economics and Policy

journal homepage: www.elsevier.com/locate/iep

The Internet and SME Participation in Exports

Meng Sun*

Business School, Beijing Normal University, No. 19 Xinjiekouwai Street, Haidian District, Beijing 100875, China

ARTICLE INFO

Article history:
Received 21 May 2020
Revised 10 May 2021
Accepted 29 June 2021
Available online 22 July 2021

JEL classification:
F1
F6

Keywords:
International trade
The Internet
E-commerce platforms
SMEs

ABSTRACT

This paper analyzes the effect of the development of the Internet on the share of small and medium-sized enterprises (SMEs) in total exports. We extend the Helpman, Melitz and Yeaple (2004) model to include the opportunity for firms to pay lower fixed export costs by exporting indirectly via well-established e-commerce platforms. SMEs self-select into the indirect exporting mode. In response to the development of the Internet, fixed costs of indirect exporting fall at a higher rate than fixed costs of direct exporting. Consequently, SMEs tend to account for a larger share in total exports as the Internet develops. Using two samples from the Exporter Dynamics Database, we find supporting evidence that the development of the Internet in the exporting country has a significant and negative effect on the share of exports by the top 5% or 25% of exporters, implying a larger share of SMEs. Moreover, we find that improved submarine cable infrastructure in the exporting country also leads to a lower share of exports by large exporters. These are in contrast to the estimated positive effect of telephone development in the exporting country, which may not disproportionately benefit indirect exporting via e-commerce platforms over direct exporting. Finally, we find an imperfect substitution relationship between e-commerce platforms and traditional intermediaries.

1. Introduction

Internet infrastructure nowadays underpins economic and social activity worldwide. Its presence alters the way firms conduct international business by dramatically reducing information frictions, search costs and communication costs and by forming the e-commerce[1] landscape. Small and medium-sized enterprises (SMEs) have been well known for their contributions to economic development and social well-being, and better access to global markets is key to strengthening SME contributions (OECD, 2019b). Whether SMEs are given more opportunities in international trade through the spread of Internet technology then becomes an important issue.

How does the development of the Internet affect the share of SME exports in total exports? The removal of trade barriers by virtue of the development of the Internet could stimulate the exports of both large firms and SMEs, but the extent of enhancement may differ. One view is that large firms may become the main beneficiaries by accounting for an even higher share in total exports as the Internet develops. Given large firms' advantages in scale and scope, they are able to exploit many new opportunities that are out of reach to individual SMEs.[2]

The other view is that the share of SME exports is likely to rise in response to the increasing penetration of the Internet. Advances in digital technologies, differing from other trade facilitation measures such as lower tariffs[3], have led to the emergence of online services and e-commerce platforms such as Alibaba, Amazon, Ecplaza, and Tradeindia. Their important intermediary role in international commerce has gained attention, as they lower barriers to starting and operating overseas businesses for SMEs, thereby realizing SMEs widespread participation in the global market (e.g., Kuwayama, 2001; OECD, 2019a; (World Trade Organization WTO, 2016) and offering them a level playing field for competing with their larger competitors (Cho and Tansuhaj, 2013). Although large firms have been early adopters of the Internet (World Bank Group, 2016), the development of the Internet may

* Corresponding author.
E-mail address: sunmeng@bnu.edu.cn

[1] OECD (2019a) defines e-commerce as the sale or purchase of goods or services, conducted over computer networks by methods specifically designed for the purpose of receiving or placing orders.

[2] Lacking economies of scale, SMEs face higher fixed costs than larger companies and are disproportionately affected by costs associated with the import and export process (World Bank Group, 2016). Freund and Pierola (2020) show that the top five exporters account for on average one third of exports over a five-year period and the share of exports in the top five firms increases significantly as exports grow. Bernard et al. (2018) present evidence that trade is disproportionately concentrated in the largest firms and global firms increase their shares of aggregate trade by participating more intensively along multiple margins.

[3] Freund et al. (2016) find that the removal of trade barriers such as a new free trade agreement stimulates the exports of large and small firms in similar ways.

https://doi.org/10.1016/j.infoecopol.2021.100940
0167-6245/

matter more to the exports of SMEs. Therefore, this is an empirical question to be explored.

To guide the empirical analysis, we propose an adaptation of the Helpman et al., 2004 model by incorporating the firm's indirect exporting technology via e-commerce platforms. The model predicts that the increasing penetration of the Internet could enhance the share of SME exports. Specifically, we consider that firms exporting via e-commerce platforms pay lower fixed export costs, but higher service fees that translate into higher variable trade costs. In the presence of well-established e-commerce platforms, all SME exporters, or even some less productive large exporters, choose to export indirectly instead of directly exporting, and only the most productive firms choose to overcome the high fixed costs of directly exporting to foreign markets. As the development of the Internet propels e-intermediaries to keep evolving and revealing more cost advantages, the fixed costs of indirect exporting fall at a higher rate than the fixed costs of direct exporting, which leads to a larger share of SME exporters and a smaller share of exports by large firms in total exports.

Our empirical examination mainly relies on the Exporter Dynamics Database, which records the share of exports by the top 1%, 5%, and 25% of exporters from 1997 to 2014. One minus each share above is employed to characterize the share of SME exports in total exports. The standard deviation of the export value per exporter in the database is employed to control for the dispersion of exporter size. The development level of the Internet, which is the key explanatory variable, is measured by the percentage of individuals in the total population that use the Internet, which is based on the World Development Indicators.

The prediction that the development of the Internet boosts the share of SME exports in total exports is empirically supported in this work. The empirical analysis takes advantage of two data samples at the exporting country-product(HS2)-destination-year level (CYH2D) and at the exporting country-product(HS6)-year level (CYH6) separately. After controlling for various country characteristics and fixed effects at the lowest possible levels to partial out corresponding unobserved variables, we find that in the exporting country, the significantly negative effect of the development of the Internet on the share of exports by the top 5% or 25% of exporters remains in both samples.

This paper contributes to the burgeoning literature on the effects of information and communication technologies (ICTs) on international trade[4] by exploring the nature of exporters in terms of their size. Although this line of literature has generally recognized the trade-liberalization effect of Internet technologies,[5] the impact may not be the same across heterogeneous firms. We employ export share instead of export flow as the dependent variable in this work. The change in the share of SME exports sheds light on the resource allocation between SMEs and large exporters, especially when their exports both increase. In addition, some common determinants of the trade flows of SMEs and large exporters are eliminated when calculating the export share theoretically so that their potential confounding effects in explaining export share could be of less concern.

The following strategies and corresponding findings are also worth noting. First, we incorporate telephone development in the empirical specification to make a comparison with the development of the Internet, considering that they both fall into the category of national telecommunication infrastructure with active roles in reducing transaction costs. In contrast to the negative effect of the Internet on the share of large exporters, we find that telephone development exerts a statistically positive effect on the share of large exporters. We interpret the evidence as reflecting the key difference that the formation of e-commerce platforms relies fundamentally on the Internet, but not on phone calls.

Second, we construct a measure of the submarine cable infrastructure, and add it as an additional regressor to control for the qualitative differences of Internet traffic across countries that are not reflected by Internet penetration. This infrastructure is the key to cross-border data transfer. Due to the heavy reliance of e-commerce platforms on system capacity and data transfer speed for their services, the trade facilitation effect of improved Internet quality could be stronger for indirect exporting than direct exporting. A higher level of the submarine cable infrastructure is found to be associated with a larger share of SME exports. In this way, we provide suggestive evidence on the potential role of e-commerce platforms that is consistent with the baseline results.

Third, by exploiting the CYH2D sample further, we find that the share of SME exports increases with the development of the Internet to a lesser extent in sectors that have more traditional intermediaries relative to other sectors. Meanwhile, sectors that have more traditional intermediaries have larger shares of SME exports than other sectors, but the difference may lessen as the Internet develops. The results shed some light on the imperfect substitution relationship between e-commerce platforms and traditional intermediaries.

Empirical works that relate the development of the Internet exclusively to the trade performance of SMEs are scarce. Lendle and Olarreaga (2017) show that online markets provide smaller firms access to international markets by using data from eBay sellers. Lanz et al. (2018) find that SMEs tend to participate more in global value chains in countries where a higher share of the population has fixed broadband subscriptions. Our study provides further evidence that the impact could be biased in favor of SMEs, as it quantitatively assesses the impact of the Internet on SMEs in terms of their share in total exports using internationally comparable data.

Research on the traditional intermediaries in international trade (e.g., Blum et al., 2010; Ahn et al., 2011; Felbermayr and Jung, 2008 and Akerman et al., 2018) has investigated the influence of traditional intermediaries on the export behavior of SMEs. To some extent, e-intermediaries act similarly to wholesalers and other traditional intermediaries in international trade. However, e-intermediaries differ from traditional trade intermediaries inasmuch as the Internet plays an elementary role in the emergence and development of e-intermediaries.

The rest of the paper is organized as follows. Section 2 introduces the theoretical framework for modeling firm heterogeneity with e-commerce platforms. Section 3 describes the empirical strategy and the data in detail. The empirical results from the CYH2D sample are presented and discussed in Section 4, while those from the CYH6 sample in Section 5. Section 6 presents the conclusions.

2. Theoretical framework with e-commerce platforms

The emergence of online services and e-commerce platforms, which exploit scale or scope economies and network externalities, allows each additional user, when doing business, to take advantage of new technologies without incurring by itself high fixed upfront costs. For example, the expansion of the Internet removes the need to set up costly electronic data interchange (EDI) network; and complementary services offered by some online platforms include fulfillment, logistics, customer service etc. (OECD, 2019a).

[4] Some examples are Abeliansky and Hilbert (2017); Ozcan (2018); Rodriguez-Crespo et al. (2018); Liu and Nath (2013), and Wang and Choi (2019).

[5] The Internet has been found to stimulate the volume of trade in goods (e.g., Freund and Weinhold, 2004; Lin, 2015; Clarke and Wallsten, 2006; Rodriguez-Crespo et al., 2019; Osnago and Tan, 2016) and the volume of trade in services (e.g., Freund and Weinhold, 2002; Choi, 2010). The impacts of Internet technology on various margins of trade involving firms (e.g., Fernandes et al., 2019; Akerman et al. 2018; Yadav, 2014), products (e.g., Riker, 2015; Huang and Song, 2019; Visser, 2019) and destinations (e.g., Lendle and Vézina, 2015) have been studied.

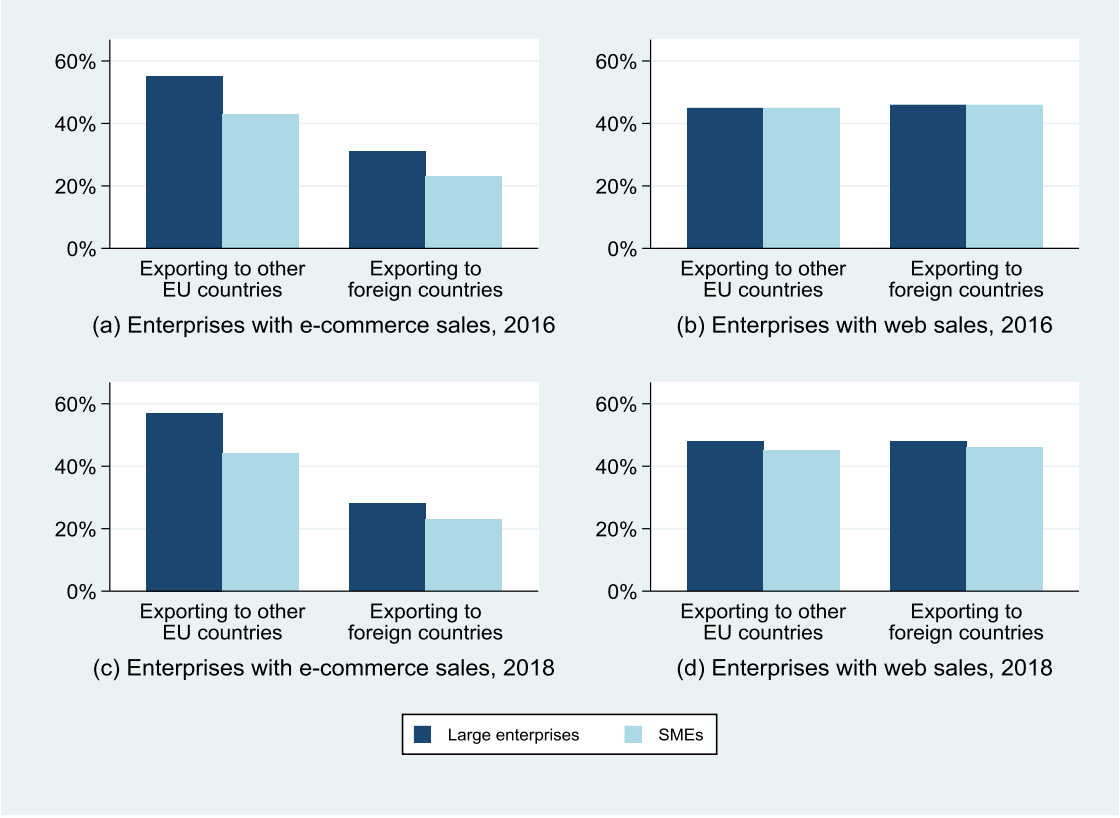

Fig. 1. Share of exporters amoung enterprises with e-commerce sales and web sales, 2016 and 2018.

The benefits from e-commerce are not constrained to domestic trade. The Internet, especially e-commerce platforms, facilitates international commerce for SMEs. Many online platforms such as eBay and Alibaba include cross-border e-commerce services, enabling SMEs to access overseas markets. For example, marketing goods globally on the internet is cheaper, and customizing market information to suit the local context and language is easier (World Bank Group, 2016). Although services are provided on a fee-for-service basis,[6] traditional fixed export costs are vastly saved or even eliminated for SME exporters. According to Freund et al. (2016), the share of SME exports is larger on eBay than via offline business models.

Compared with large exporters that are able to keep large upfront investments inhouse, SMEs disproportionately benefit from the cross-border online platform services that can be outsourced at ultra-low costs by virtue of digital technologies. As an illustration of the potential empirical relevance, we present two descriptive findings by utilizing data from the Eurostat "Digital Economy and Society" comprehensive database[7], which records results from surveys on the usage of information and communication technologies in enterprises in the European Union (EU).

First, the disparity between large enterprises and SMEs in export participation is much smaller for web sales. Figure 1 plots the percentage of enterprises that export by size class[8] and sales channel in 2016 and 2018[9]. Among enterprises in the EU-27 with general e-commerce sales (which consist of both web sales and EDI-type sales[10]) in 2016 (Panel a), the share of enterprises that export to other EU countries for large enterprises is distinctly larger than that for SMEs. The gap between large enterprises and SMEs remains for the percentage of enterprises that export to foreign countries (other EU countries and the rest of the world) in Panel a. Meanwhile, in Panel a, the share of enterprises that export to foreign countries for large enterprises (31%) and that for SMEs (23%) are lower than their counterparts to other EU countries (55% for large enterprises and 43% for SMEs), implying that engaging in

[6] Internet intermediaries use different business models including advertising, paid subscriptions or renting hosting space, charging for premium services, commission fees, voluntary donations, or combinations of these business models (OECD, 2011). For example, Business Finland (2020) presents the cost structures for several marketplaces in January 2020, including Amazon (commission on sales, service fees, and marketplace advertising fees) from which a seller can purchase warehousing, fulfilment and returns handling services with 300-400 million monthly users; Bol.com (fixed sales fee, commission on sales, service fees, and marketplace advertising fees) with 15 million monthly users; eBay (listing fee, final value fee on sales, service fees, and advertising fees) which does not offer warehousing with 110 million monthly users; and Tmall (with deposit at 25k, yearly fee at 5k-10k depending on the category, additional categories at $5k-10k yearly fee, sales commission at 2%-4%, and payment for providers' commission at 1%) with 500 million monthly users. Moreover, it indicates that the costs associated with becoming market compliant, product preparation, shipping, and possible local customer service should also be included, not just the direct marketplace costs.

[7] https://ec.europa.eu/eurostat/web/digital-economy-and-society/data/comprehensive-database (NACE Revision 2, V.10 March 2021, online table code: isoc_ci_eu_en2.).

[8] SMEs are enterprises with 10-249 persons employed, and large enterprises have 250 employees or more.

[9] The data are organized in Eurostat's online database according to the year in which the survey was conducted: 2011, 2013, 2015, 2017 and 2019 for enterprises with e-commerce sales to foreign countries, but only 2017 and 2019 for enterprises with web sales to foreign countries. Data on e-commerce refer to the calendar year preceding the survey (in other words, to 2016 for the 2017 survey, and to 2018 for the 2019 survey).

[10] According to Eurostat, for the Community survey on ICT usage and e-commerce in enterprises, e-commerce refers to the placement of orders via computer networks. Web sales allow for online ordering or reservation or booking. Electronic Data Interchange (EDI) e-commerce refers to structured transmission of data or documents between enterprises by electronic means allowing automatic processing using for example EDI format or XML format.

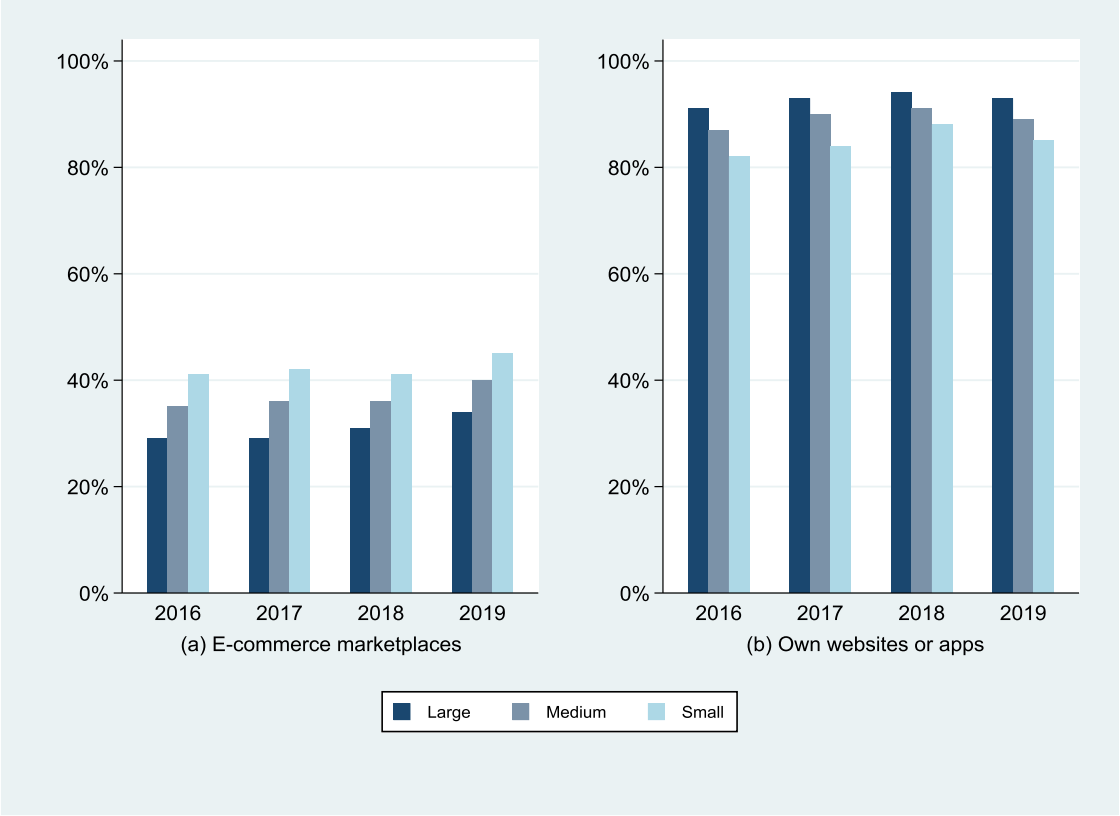

Fig. 2. Rate of adopting e-commerce marketplace versus own websites or apps by enterprises with web sales, 2016-2019

non-EU markets is more expensive with e-commerce sales. Similar patterns emerge using data in 2018 as shown in Panel c of Figure 1. By contrast, among enterprises in the EU-27 with web sales, the percentage of SMEs that export to other EU countries and that to foreign countries are equal to the corresponding shares in large enterprises in 2016 (Panel b), and slightly less in 2018 (Panel d). It provides suggestive evidence that SMEs are not at a clear disadvantage compared to large enterprises when exporting via web sales. Web sales play an important role for SMEs in having access to foreign countries, especially to distant international markets.[11]

Second, the rate of adopting e-commerce marketplaces among enterprises with web sales for SMEs surpasses that for large enterprises. Figure 2 presents the breakdown by sales channel used by enterprises that made web sales. The information is split between those enterprises that made web sales via e-commerce marketplaces (Panel a) and those enterprises that made web sales via their own website or apps (Panel b). In the EU-27 from 2016 to 2019 for which data are available, Figure 2 shows that the share of enterprises with web sales via e-commerce marketplaces decreases with size[12], whereas the share of enterprises with web sales via their own websites or apps increases with size for each year.[13] For example, as shown in Panel a, among enterprises with web sales in 2016, large enterprises have the lowest percentage of enterprises that use e-commerce marketplaces, with 29%. For medium-sized enterprises, the percentage rises to 35% and for small enterprises it rises to 41%, suggesting the importance of e-commerce marketplaces for SMEs. The opposite trend emerges for the share of enterprises that use their own websites or apps as shown in Panel b. Among enterprises with web sales, large enterprises are those with the highest share of enterprises that use their own websites or apps, followed by medium-sized enterprises and small enterprises. Large enterprises may rely more on the web sales via own websites or apps relative to SMEs because they could have excellent traffic on their own websites and mobile apps and tend to avoid additional platform fees. Moreover, the platforms usually do not give sellers direct access to full customer data and have strict rules on transactions.

The following provides a theoretical framework for understanding how the share of SME exports in total exports changes as the Internet develops in the existence of e-commerce platforms. We employ the Helpman, Melitz and Yeaple (HMY, 2004) model, which features an exports-versus-FDI[14] trade-off for the firm in a Melitz-type environment, with a minor adaptation. The basic assumptions on market structure, firm heterogeneity and consumer preferences are the same as those used in HMY. Our main point of departure from the HMY model is that the trade-off firms face here is whether to export directly or indirectly via e-commerce platforms.

Consider a standard monopolistic competition model with firm heterogeneity.[15] For a sector supplying a continuum of horizontally differentiated varieties, the demand for each variety ω is given by $q(\omega) = Ap(\omega)^{-\sigma}$, where q is the demand quantity, p is the price, A is an index of market demand, and $\sigma > 1$ is the constant demand elasticity. A firm draws its productivity φ from the cumulative distribution $G(\varphi)$ after paying the sunk entry cost. This profit-maximizing firm then charges a constant mark-up over marginal

[11] According to World Trade Organization (2018), when using the difference in the proportion of exporters amongst overall enterprises instead of that amongst enterprises with e-commerce sales as the reference, the disparity between large enterprises and SMEs in export participation is also considerably smaller for web sales.

[12] Small enterprises: 10-49 persons employed; medium enterprises: 50-249 persons employed; and large enterprises: 250 or more persons employed.

[13] Similar results are reported in World Trade Organization (2018) using data in 2015. The data is not available in the data portal anymore.

[14] Foreign direct investment

[15] We employ the stylized forms and notations in Melitz and Redding (2014).

cost so that its profit from serving the domestic market is $\pi_D = \varphi^{\sigma-1}B - f_D$, where $B = \frac{1}{\sigma}(\frac{\sigma-1}{\sigma})^{\sigma-1}A$ and f_D denotes the fixed production cost.[16]

Assume N countries with trade costs in the world economy. To export directly, a firm must incur fixed export costs of f_X per foreign market and ship $\tau > 1$ units for each unit to arrive. Direct exporting to market j yields additional profits $\pi_X^{ij} = \left(\tau^{ij}\right)^{1-\sigma}\varphi^{\sigma-1}B^j - f_X^i$ for a firm with productivity φ in country i.

Firms can alternatively choose to indirectly serve the foreign markets via e-commerce platforms. The presence of e-commerce platforms enables firms to export at much lower fixed costs $f_O < f_X$ for a fee.[17] We assume that platform service fees increase variable trade costs to $\gamma\tau$ where $\gamma > 1$. Under this indirect export mode, the profits from export sales in country j then become $\pi_O^{ij} = \left(\gamma^{ij}\tau^{ij}\right)^{1-\sigma}\varphi^{\sigma-1}B^j - f_O^i$.

Given these three profit functions, π_D^i, π_X^{ij}, and π_O^{ij}, we have the following three zero-profit conditions for each pair of source country and destination market: $\pi_D^i\left(\varphi_D^i\right) = 0$, $\pi_O^{ij}\left(\varphi_O^{ij}\right) = 0$, and $\pi_X^{ij}\left(\varphi_X^{ij}\right) - \pi_O^{ij}\left(\varphi_X^{ij}\right) = 0$, where φ_D^i, φ_O^{ij}, φ_X^{ij} are the productivity cutoffs respectively. Accordingly, we have

$$\left(\varphi_D^i\right)^{\sigma-1}B^i = f_D^i, \tag{1}$$

$$\left(\gamma^{ij}\tau^{ij}\right)^{1-\sigma}\left(\varphi_O^{ij}\right)^{\sigma-1}B^j = f_O^i, \forall j \neq i, \tag{2}$$

$$\left(\tau^{ij}\right)^{1-\sigma}\left[1 - \left(\gamma^{ij}\right)^{1-\sigma}\right]\left(\varphi_X^{ij}\right)^{\sigma-1}B^j = f_X^i - f_O^i, \forall j \neq i. \tag{3}$$

The free entry conditions, together with the zero-profit conditions (Equations 1-3), jointly determine all the equilibrium cutoffs (φ_D^i, φ_O^{ij}, φ_X^{ij}) and market demand levels (B) implicitly. We obtain the cutoff ratio

$$\frac{\varphi_X^{ij}}{\varphi_O^{ij}} = \left[\frac{f_X^i - f_O^i}{f_O^i}\frac{1}{\left(\gamma^{ij}\right)^{\sigma-1} - 1}\right]^{\frac{1}{\sigma-1}} \tag{4}$$

by combining Equations (2) and (3).

For the special case of equal demand levels, the zero-profit cutoffs are illustrated in Figure 3. Direct export profits π_X^{ij} increase less steeply with firm productivity than domestic profits π_D^i due to variable trade costs. Platform fees lead to an even less steep slope of the platform export profit function π_O^{ij} than that of the direct export profits π_X^{ij}. Given the increasing order of fixed costs ($f_D^i < f_O^i < f_X^i$), firms select into different modes.[18] The sorting pattern shows that firms with productivity levels above φ_X^{ij} gain more by accessing foreign markets directly. Firms that draw a productivity between φ_O^{ij} and φ_X^{ij} choose to export via e-commerce platforms. Although cross-border transactions are undertaken at higher variable costs due to platform fees, they save on fixed export costs to a large extent.

We present predictions that will guide the empirical analysis based on our definition of the large-exporter cutoff (discussed as follows). In the classic heterogeneous firm model, the most productive firms produce greater output and are more profitable in all activities. Therefore, we define firms with productivity levels above φ_T^{ij} as large exporters, and firms with productivity levels between φ_O^{ij} and φ_T^{ij} as small and medium-sized exporters. Specifically, by considering the top n% of exporters to be large exporters, we have

$$1 - G^i(\varphi_T^{ij}) \triangleq n\%\left[1 - G^i(\varphi_O^{ij})\right] \tag{5}$$

where $G^i(\varphi)$ is the cumulative distribution of productivity in country i. For the empirical examination, the top 1%, 5% and 25% of exporters are alternatively regarded as the top n% of exporters. That is, the large-exporter cutoff coefficient φ_T^{ij} is not endogenously determined. To derive quantitative predictions, we further impose the Pareto distribution assumption with shape parameter $k^i > \sigma - 1$ for firm productivity.[19] Then, threshold φ_T^{ij} can be expressed as $\varphi_T^{ij} = (n\%)^{-\frac{1}{k^i}}\varphi_O^{ij}$ by rearranging Equation (5).

The starting point is that φ_O^{ij} coincides with φ_X^{ij} ($\frac{\varphi_X^{ij}}{\varphi_O^{ij}} = 1$), which are both smaller than φ_T^{ij}. This is the case when the e-commerce platforms do not exhibit any advantages over direct exporting so that all exporters choose to export directly. Next, for $1 < \frac{\varphi_X^{ij}}{\varphi_O^{ij}} < (n\%)^{-\frac{1}{k^i}}$, we have $\varphi_O^{ij} < \varphi_X^{ij} < \varphi_T^{ij}$; for $\frac{\varphi_X^{ij}}{\varphi_O^{ij}} > (n\%)^{-\frac{1}{k^i}}$, the ordering satisfies $\varphi_O^{ij} < \varphi_T^{ij} < \varphi_X^{ij}$. We discuss the latter two cases below:

Case 1. Superior e-commerce platforms with all SME exporters selecting into exporting via the indirect export mode ($\varphi_T^{ij} < \varphi_X^{ij}$)

We consider this case to correspond to an economy in which for all SME exporters, indirect exporting via e-commerce platforms shows superiority over direct exporting. The large-exporter cutoff coefficient is denoted by φ_T^{ij}, as illustrated in Figure 3. It is evident that in this case, all SME exporters select the indirect export mode. Less productive large exporters also choose to export indirectly via e-commerce platforms. Only the most productive large exporters export directly. Since online businesses are successful and effective in attracting all SME exporters to conduct indirect exporting, we describe the case as indirect exporting in the presence of superior e-commerce platforms.

We find that the share of exports by large firms decreases as the Internet develops. The share of exports by large firms in total exports from country i to country j is denoted as $Share^{ij} = \frac{V_{TX}^{ij} + V_{XX}^{ij}}{V_{OX}^{ij} + V_{XX}^{ij}}$, where $V_{TX}^{ij} = \int_{\varphi_T^{ij}}^{\varphi_X^{ij}} \sigma\left(\gamma^{ij}\tau^{ij}\right)^{1-\sigma}\varphi^{\sigma-1}B^j g(\varphi)d\varphi$ for large exporters that choose to export indirectly, $V_{XX}^{ij} = \int_{\varphi_X^{ij}}^{\infty} \sigma\left(\tau^{ij}\right)^{1-\sigma}\varphi^{\sigma-1}B^j g(\varphi)d\varphi$ for large exporters that export directly, $V_{OX}^{ij} = \int_{\varphi_O^{ij}}^{\varphi_X^{ij}} \sigma\left(\gamma^{ij}\tau^{ij}\right)^{1-\sigma}\varphi^{\sigma-1}B^j g(\varphi)d\varphi$ for the SME and large exporters which export indirectly, and $g(\varphi)$ is the distribution density of productivity summarizing the firm-level productivity heterogeneity in a sector.

[16] Wage w is normalized to be 1.

[17] In the studies that investigate the role of wholesalers in international trade, the assumption is quite common that a number of manufacturing firms may export indirectly through a wholesaler, rather than managing their own distribution networks, by paying an intermediary fixed cost, which is smaller than their own fixed cost of direct export (e.g., Bernard et al., 2015 and Crozet et al., 2013). Meanwhile, indirect exporting via wholesalers is assumed to incur a higher marginal cost because of the double marginalization by wholesalers or an additional marginal cost of selling abroad, such as re-labeling and packaging (Ahn et al., 2011). Empirically, Fujii et al. (2017) find evidence of larger fixed costs but lower variable costs of direct exporting compared with the alternative of indirect exporting via traditional intermediaries using large-scale Japanese interfirm transaction network data. E-commerce platforms benefit exporters in a similar way to traditional intermediaries, and maybe to a larger extent. As stated in World Trade Organization (2018), many of the services offered by online platforms have traditionally been supplied by large wholesalers and retailers, which act as export intermediaries and facilitate indirect exports for smaller firms. Our assumption for the e-commerce platforms is thus in accordance with that for the traditional intermediaries.

[18] It requires $\left(\gamma^{ij}\tau^{ij}\right)^{\sigma-1}f_O^i > f_D^i$ and $f_X^i > \left(\gamma^{ij}\right)^{\sigma-1}f_O^i$ to ensure a positive mass of firms engaged in direct and indirect exporting.

[19] $g(\varphi) = k\varphi_{\min}^k\varphi^{-k-1}$ where $\varphi_{\min} > 0$.

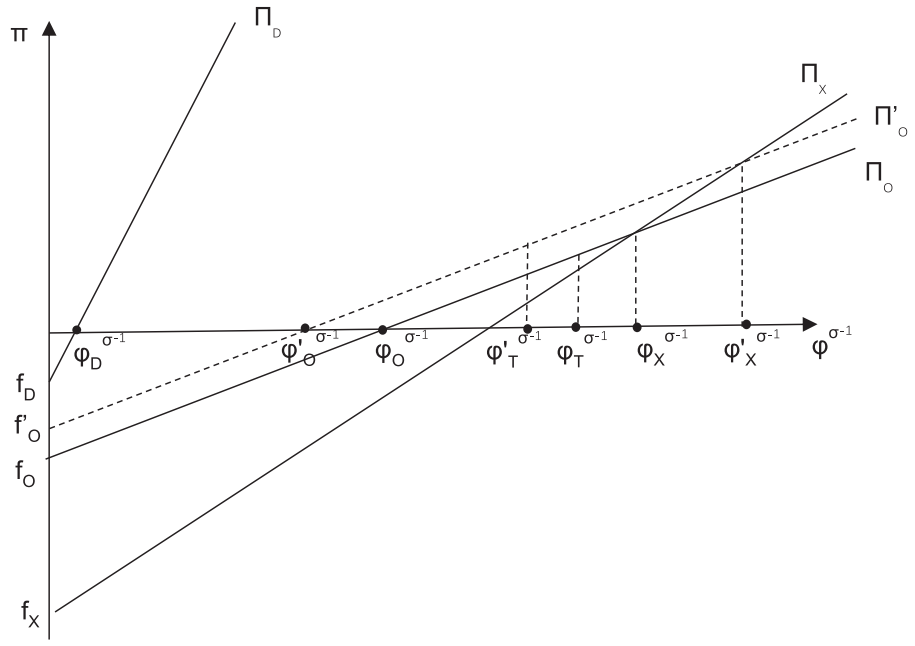

Fig. 3. Profits and productivity with superior e-commerce platforms

We show in Appendix A1 that the share of exports by large firms can be expressed as

$$Share^{ij} = \frac{\left[1-\left(\gamma^{ij}\right)^{1-\sigma}\right]\left[\frac{f_X^i-f_0^i}{f_0^i}\frac{1}{\left(\gamma^{ij}\right)^{\sigma-1}-1}\right]^{\frac{\sigma-k^i-1}{\sigma-1}}+\left(\gamma^{ij}\right)^{1-\sigma}(n\%)^{\frac{k^i-(\sigma-1)}{k^i}}}{\left[1-\left(\gamma^{ij}\right)^{1-\sigma}\right]\left[\frac{f_X^i-f_0^i}{f_0^i}\frac{1}{\left(\gamma^{ij}\right)^{\sigma-1}-1}\right]^{\frac{\sigma-k^i-1}{\sigma-1}}+\left(\gamma^{ij}\right)^{1-\sigma}}. \tag{6}$$

From the definition of $\varphi_T^{ij} = (n\%)^{-\frac{1}{k^i}}\varphi_0^{ij} > \varphi_0^{ij}$, it is clear that $(n\%)^{-\frac{1}{k^i}} > 1$ so that $(n\%)^{\frac{k^i-(\sigma-1)}{k^i}} < 1$. Thus, Equation (6) implies that $Share^{ij}$ is an increasing function of $\frac{f_0^i}{f_X^i}$, all else being equal.

Within this theoretical framework, we regard the development level of the Internet as a key determinant of the relative fixed export costs ($\frac{f_0^i}{f_X^i}$). With the maturation and increasing penetration of the Internet, internet intermediaries have continued to evolve since their advent. E-commerce platforms are poised to connect an increasing number of users, information, and services, and at faster speeds (OECD, 2011). In this regard, we consider the benefits from those more comprehensive, efficient and up-to-date services to be reflected by the reduced relative fixed export costs (a lower $\frac{f_0^i}{f_X^i}$).[20] That is, as the fixed costs of direct exporting f_X^i decrease, the fixed costs of indirect exporting f_0^i could decrease at an even higher rate. The development of the Internet leads to a smaller relative fixed export costs $\frac{f_0^i}{f_X^i}$, which implies that SMEs could capture a larger share in total exports (a smaller $Share^{ij}$).

Specifically, we illustrate in Figure 3 the case in which f_0^i decreases as the Internet develops. The dashed line Π_0' depicts profits for firms that export indirectly via e-commerce platforms, as the platform's fixed costs decrease from f_0 to f_0'. Firms with productivity levels between φ_0' and φ_0 are new SMEs that are starting to export via e-commerce platforms. Existing SMEs and large exporters that export via e-commerce platforms ($\varphi_0 < \varphi < \varphi_T$ and $\varphi_T < \varphi < \varphi_X$) stick to their strategies and have larger profits by taking advantage of the more developed platforms. This also allows some original SME exporters ($\varphi_T' < \varphi < \varphi_T$) to grow into large exporters.[21] Meanwhile, the lower platform fixed costs drive some large exporters ($\varphi_X < \varphi < \varphi_X'$) to switch from direct exporting to indirect exporting to earn more. We note that the aggregate exports of both SMEs and large firms increase. However, because most large exporters ($\varphi > \varphi_X'$) earn the same profits by exporting directly, the increase in exports by large firms is limited, leading to a smaller share of exports by large firms.[22]

To summarize, in this case, all SMEs benefit from the development of the Internet because of their engagement in the indirect export mode. The model proposes that all else being equal, the share of exports by large exporters decreases as the exporting country's Internet develops, which entails larger shares of SME exports in the total exports.

Case 2. Inferior e-commerce platforms with the most productive SME exporters choosing direct exporting over indirect exporting ($\varphi_T^{ij} > \varphi_X^{ij}$)

[20] We assume implicitly that the exporting country's Internet development, which acts as the basis of the local e-commerce platforms that reduce outbound fixed costs, does not differently affect the inbound fixed costs into each destination country, such that we do not consider the fixed export costs (f_0^i and f_X^i) to be bilateral in the theoretical model.

[21] Given $\varphi_T^{ij} = (n\%)^{-\frac{1}{k^i}}\varphi_0^{ij}$, φ_T^{ij} decreases with a reduction in φ_0^{ij}, all else equal.

[22] We only consider a lower f_0 for simplicity of exposition. Nevertheless, as long as $\frac{f_0^i}{f_X^i}$ keeps falling, the result that the aggregate exports by large firms do not increase as much as those by SMEs is robust to a decrease in f_X. Equation (6) also implies that the share of exports by large firms decreases if platform fees γ are reduced or if not raised too much, conditional on a fall in $\left[\left(\gamma^{ij}\right)^{1-\sigma}-1\right]\left[\frac{f_X^i-f_0^i}{f_0^i}\frac{1}{\left(\gamma^{ij}\right)^{\sigma-1}-1}\right]^{\frac{\sigma-k^i-1}{\sigma-1}}$ along with a reduction in $\frac{f_0^i}{f_X^i}$. Economic development might be a driving force in reducing commission fees by reducing operational costs and mitigating risks, among other factors that affect commission rates, such as the e-commerce market structure. According to a survey by the International Trade Centre (2017), businesses based in African countries suffer from high commission rates on sales, which are charged by e-commerce platforms to mitigate risks and recover expected high operational costs. These commissions, when charged to developing country firms, may reach 40 percent, almost three times the 15 percent upper bound commissions in developed countries. (World Trade Organization, 2018) Nevertheless, evidence for a systematic relationship between the development of the Internet and the change in variable trade costs attributed to e-commerce platform fees is not available yet.

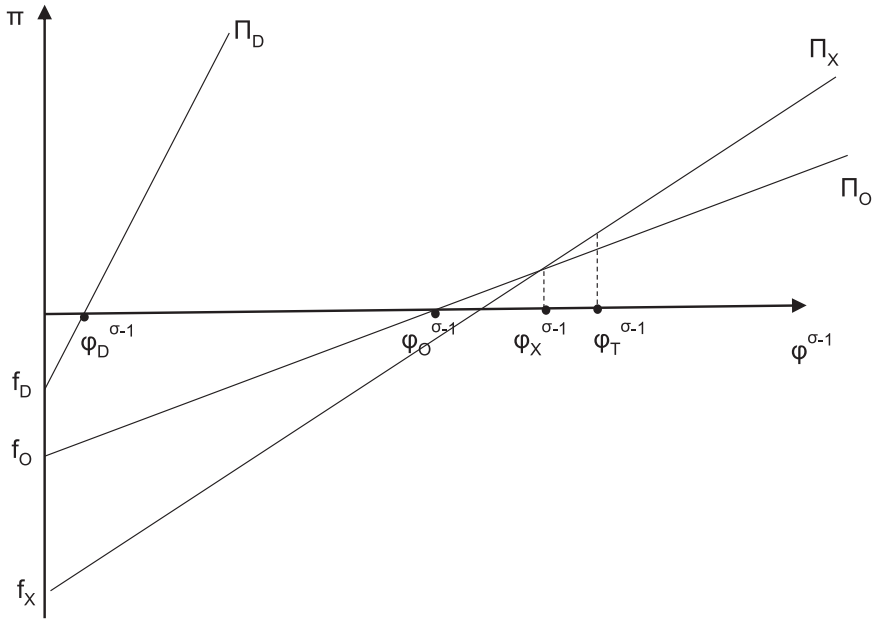

Fig. 4. Profits and productivity with inferior e-commerce platforms

This case is regarded as corresponding to an economy in which for some of the SME exporters, indirect exporting via e-commerce platforms is not superior to direct exporting. In Figure 4, the large-exporter cutoff coefficient is denoted by φ_T^{ij}. All large exporters choose to export directly. The most productive SMEs also export directly, while the other SME exporters select into the indirect export mode. Because the e-commerce platforms are less developed and the most productive SME exporters prefer to export directly, we describe this case as indirect exporting in the presence of inferior e-commerce platforms.

The share of exports by large firms from country i to country j is denoted as $Share^{ij} = \frac{V_{TT}^{ij}}{V_{OX}^{ij}+V_{XX}^{ij}}$, where $V_{TT}^{ij} = \int_{\varphi_T^{ij}}^{\infty} \sigma\left(\tau^{ij}\right)^{1-\sigma} \varphi^{\sigma-1} B^j g(\varphi) d\varphi$ for large exporters that all export directly, $V_{OX}^{ij} = \int_{\varphi_O^{ij}}^{\varphi_X^{ij}} \sigma\left(\gamma^{ij}\tau^{ij}\right)^{1-\sigma} \varphi^{\sigma-1} B^j g(\varphi) d\varphi$ for SME exporters that export indirectly, and $V_{XX}^{ij} = \int_{\varphi_X^{ij}}^{\infty} \sigma\left(\tau^{ij}\right)^{1-\sigma} \varphi^{\sigma-1} B^j g(\varphi) d\varphi$ for all the direct exporters. By imposing the Pareto distribution assumption, we express the share of exports by large firms as follows

$$Share^{ij} = \frac{(n\%)^{\frac{k^j-(\sigma-1)}{k^j}}}{\left[1-\left(\gamma^{ij}\right)^{1-\sigma}\right]\left[\frac{f_X^i-f_O^i}{f_O^i}\frac{1}{\left(\gamma^{ij}\right)^{\sigma-1}-1}\right]^{-\frac{k^j-(\sigma-1)}{\sigma-1}} + \left(\gamma^{ij}\right)^{1-\sigma}}. \tag{7}$$

The details are illustrated in Appendix A2. Equation (7) shows that the share of exports by large firms decreases in $\frac{f_O^i}{f_X^i}$. In light of the discussion above regarding the role of Internet development in reducing $\frac{f_O^i}{f_X^i}$, Equation (7) predicts a positive relationship between the development of the Internet and the share of exports by large firms all else being equal. In this case, the additional benefit arising from platform development as a result of higher Internet penetration can only accrue to some of the SMEs that export indirectly, not all of the SMEs.

Overall, for the two cases, conditional on whether the e-commerce platforms are superior or inferior, the theoretical framework provides opposite predictions regarding the linkage between the development of the Internet and the share of exports by large exporters.[23] This becomes an empirical question, which is explored in the following analysis. In particular, we investigate whether the evidence supports the prediction that *the share of SME exports could be enhanced through the development of the Internet*, as proposed in Case 1. This could have important implications in recognizing the favorable impact of the development of the Internet on SMEs.

3. Empirical strategy and data description

3.1. Empirical specification

To explore the effect of the Internet on the share of SME exports in total exports empirically, we consider the following speci-

[23] In our model, we assume that firms exporting indirectly pay lower fixed export costs and higher service fees that translate into higher variable trade costs for trade via e-commerce platforms. This assumption makes it possible for the most productive firms (large firms) to find direct exporting most profitable, and for moderately productive firms (SME exporters) to refer indirect exporting via e-commerce platforms to conserve on fixed costs. We now discuss various modifications of these key assumptions that could lead to different productivity sorting patterns of firms regarding their exporting modes. First, when we assume that e-commerce platforms raise the fixed costs and lowers the variable costs for trade, both direct and indirect exporting are allowed theoretically. However, only the most productive firms can cover the fixed costs of indirect exporting via e-commerce platforms, while less productive SMEs export directly to foreign markets. This predicted sorting along productivity lines, with indirect exporters being more productive (larger) than direct exporters, is not consistent with the fact that SMEs are pervasive on e-commerce platforms. For example, according to a 2018 survey of mostly U.S.-based Amazon sellers, 73 percent of businesses only had one to five employees (https://www.statista.com/statistics/886904/amazon-seller-business-size-by-employees/). International Trade Centre (2017) finds that more than 80% of respondents that engage solely in cross-border e-commerce are micro or small-sized firms. Second, for the polar cases in which indirect exporters that use e-commerce platforms have to face both additional fixed and variable costs of exporting or they are offered both reduced fixed and variable costs of exporting compared with direct exporters, we would observe all exporters choosing direct exporting or indirect exporting similarly. These alternative predictions with concordant strategies for all exporters are not as realistic as the one considered in our original model.

fication:

$$Share_{chdt} = \alpha + \beta_1 Internet_{ct} + \beta_2 Phone_{ct} + \beta_4 Dispersion_{chdt} + \beta_5 Z_{ct} + \lambda_{chd} + \eta_{hdt} + \epsilon_{chdt}, \quad (8)$$

where $Share_{chtd}$ is the outcome variable denoting the logarithm of the share of exports by large exporters in industry h at the HS 2-digit level from source country c to destination country d in year t. Correspondingly, $1 - e^{Share^{ij}}$ represents the share of SME exports in total exports. $Internet_{ct}$ and $Phone_{ct}$ are our measures of the levels of Internet and phone development in the source country, respectively. $Dispersion_{chdt}$ refers to the exporter-size dispersion, and Z_{ct} is a vector of the exporting country characteristics that may vary overtime. λ_{chd} and η_{hdt} are fixed effects.

It is worth noting that we investigate the Internet's effect on SMEs' trade behavior in terms of trade share instead of trade flows. The share of SME exports reflects the degree of SME participation in the global markets even when the export flows of SMEs and large firms both increase. The change in trade shares sheds light on the resource reallocation across heterogeneous exporters. Empirically, using export share as the dependent variable alleviates some concerns about the confounding effects of many common factors that affect the export flows of large firms and those of SMEs. Recall that when we calculate theoretically the ratio of cutoff values ($\frac{\varphi_X^{ij}}{\varphi_O^{ij}}$), as shown in Equation (4), factors affecting trade flows that are common to both SMEs and large exporters, such as B^j and τ^{ij}, are eliminated by taking advantage of the multiplicative structures of Equations (2) and (3).

The coefficient estimate on *Internet* provides information about the effect of an exporting country's Internet development on the share of exports by large exporters. In the theoretical framework, we consider that the exporting country's development of the Internet, which is a source country's characteristic, helps the local e-commerce platforms evolve. This results in lower relative outbound fixed costs ($\frac{f_O^i}{f_X^i}$), and then affects the share of SME exports. A negative coefficient on *Internet* showing that the share of exports by large exporters decreases as the Internet develops could lend support to the theoretical prediction formulated in Case 1 in Section 2, which suggests that a country's Internet development enhances export opportunities for SMEs. Moreover, the theory predicts that the chance of finding a negative coefficient on *Internet* is greater as a larger proportion of exporters is defined as top exporters. All else being equal, the larger the value of n%, the more likely it is that the large-exporter cutoff φ_T is smaller than the direct-exporter cutoff φ_X, which is the condition marked in Case 1. Empirically, we make use of the data on the share of exports by the top 1%, 5%, and 25% of exporters and treat each of them as the alternative measure of the dependent variable. According to our data sample (to be introduced later), the top 1%, 5% and 25% of exporters, on average, account for 32 percent, 53 percent and 78 percent of overall exports, respectively.

Incorporating *Phone* into the specification has two benefits: first, including *Phone* enables comparison with *Internet*. Despite their similarities, a key difference is that the Internet is the heart of online e-commerce platforms, not the phone. Accordingly, the Internet is indispensable for the unparalleled reduction of fixed export costs via e-commerce platforms, which then may facilitate SME exports, as our theory in Case 1 predicts. In contrast, the effect of phone usage on reducing trade costs could be even to all exporters, or be biased toward large exporters. A significantly negative estimated coefficient on *Internet* in stark contrast to a significantly positive estimated coefficient on *Phone*, which turns out to be the empirical findings, reveals that the distinctive savings of fixed export costs via e-commerce platforms are the salient feature of our data. Second, omitted variable bias could be of less concern by controlling for *Phone* . As is well known, phone calls have helped reduce transaction costs for firms and individuals, which in many ways is similar to the Internet. For example, communication costs are reduced as remote transactions are negotiated via telephone or online. Meanwhile, the development of both phone and Internet networks has been enabled by advances in the telecommunication infrastructure.[24] From the traditional dial-up internet access that establishes a connection by dialing a telephone number on a conventional telephone line to the broadband connections that often allow the Internet, phone and TV services to be bundled by one provider, many factors that are correlated with telephone development may also play important roles in the development of the Internet. Numerous common determinants could then be captured by *Phone* , and the potential bias caused by them could be reduced.

Controlling for the variation in the exporter-size dispersion *Dispersion*, which theoretically depends on parameters k^i and σ, is important given its role in deciding the ordinal relationship between φ_X and φ_T and in calculating the aggregate export sales. The basic elements of Z are the logarithm of GDP ($\ln GDP$) and the logarithm of GDP per capita ($\ln GDPpc$). The other attributes, namely, capital-labor ratio (KL), exchange rate (xr), and research and development ratio (RD), are also included to control for the differences across the source countries over time.

λ_{chd} and η_{hdt} indicate the exporting country-product(HS2)-destination and product(HS2)-destination-year fixed effects. We introduce these two three-way fixed effects to partial out the effects of the unobserved variables that are invariant within each exporting country-product(HS2)-destination group or within each product(HS2)-destination group over time. For example, λ_{chd} can control for the variation in the platform fees γ^{ij} across bilateral trading countries and products at the HS 2-digit level.[25] It also captures the variation in the time-invariant fixed costs that are specific to the product at the HS 2-digit level and each trading pair. η_{hdt} is employed to control for the destination country characteristics, including the differences in fixed entry costs across destination countries and across products (HS2) over time. These fixed effects are at the lowest possible levels, given that we are interested in the ordinary least squares (OLS) estimates of β_1 at the exporting country level over time.

3.2. Data description

Our data are mainly drawn from two sources provided by the World Bank. One is the Exporter Dynamics Database, which contains measures on the characteristics of exporters at various levels. The data we use in our analysis are separately at the exporting country-product(HS2)-destination-year (CYH2D) and at the exporting country-product(HS6)-year (CYH6) levels.[26] Data are available for the period between 1997 and 2014. We use the share of the top 1%, 5%, and 25% of exporters taken from this database to measure alternatively the share of exports by large firms in total exports. The dataset also provides information on the standard deviation of export value per exporter. This is employed to measure *Dispersion*.

The other data source we rely on is the World Development Indicators. The principal indicator of interest is the percentage of individuals using the Internet in the total population. It is used to measure the Internet development level, which is the key explanatory variable *Internet*. Similarly, the indicator of the percentage of the fixed telephone subscriptions provides data on the phone de-

[24] Both narrowband and ADSL broadband rely for their delivery on the Public Switched Telephone Network (PSTN) in the UK. (DeStefano et al., 2018)

[25] The platform fees are assumed to be time invariant in the theoretical framework.

[26] The data files are titled "CYH2D_all" and "CYH6_all" in the database.

Table 1
Share of exports by large exporters and the Internet. CYH2D.

VARIABLES	(1) 1%	(2) 5%	(3) 25%	(4) 1%	(5) 5%	(6) 25%
Internet	-0.217**	-0.136***	-0.0809***	-0.120	-0.135***	-0.0983***
	(0.0874)	(0.0245)	(0.00748)	(0.0961)	(0.0276)	(0.00911)
Phone	0.296**	0.352***	0.250***	0.316**	0.350***	0.269***
	(0.132)	(0.0373)	(0.0119)	(0.141)	(0.0397)	(0.0127)
Disperse	1.199***	0.402***	0.175***	1.072***	0.525***	0.191***
	(0.222)	(0.106)	(0.0245)	(0.210)	(0.0910)	(0.0242)
lnGDP	0.448*	-0.149**	-0.113***	0.231	-0.345***	-0.243***
	(0.255)	(0.0641)	(0.0177)	(0.346)	(0.0936)	(0.0270)
lnGDPpc	-0.949***	-0.205***	-0.0119	-1.010***	-0.0952	0.0715**
	(0.289)	(0.0717)	(0.0202)	(0.387)	(0.103)	(0.0301)
KL				0.325	0.150	0.0172
				(0.393)	(0.0913)	(0.0232)
xr				0.0920	-0.602**	-0.234***
				(1.290)	(0.291)	(0.0840)
RD				-0.0314	0.00615	0.00374
				(0.0418)	(0.0121)	(0.00387)
Exporter-H2-Destination FEs	Y	Y	Y	Y	Y	Y
H2-Destination-Year FEs	Y	Y	Y	Y	Y	Y
Observations	21,274	146,419	522,612	16,737	108,933	357,434
R-squared	0.853	0.785	0.674	0.854	0.799	0.708

Notes: Dependent variables are the logarithm of the share of exports by the top 1%, 5% and 25% of exporters respectively. Robust standard errors clustered at the exporting country-product(HS2)-destination country level in parentheses. *** Significant at 1% level, ** Significant at 5% level, * Significant at 10% level.

velopment level (*Phone*). Regarding the time-variant country attributes, the indicators include GDP and GDP per capita, which are employed to calculate the logarithm of GDP (ln *GDP*) and the logarithm of GDP per capita (ln *GDPpc*), respectively. The research and development expenditure as a percentage of GDP is used to measure the R&D level (*RD*).

In addition, data on exchange rate (*xr*) and capital-labor ratio (*KL*)[27] are from the World Penn Table (version 9.1). We also adjust the units of the following independent variables to scale up their estimated coefficients because their estimated coefficients are too small to be conveniently printed in the output and interpreted: *Cable* is divided by 10^2, *Dispersion* by 10^8, and *xr* by 10^4.

4. Empirical findings from the CYH2D sample

The sample at the exporting country-product(HS2)-destination-year level (CYH2D) serves as the basis for the analysis in this section. It consists of 58 exporting countries, with partial or entire time spans ranging from 1997 to 2014. The full exporting country list for the sample can be found in Table B.1. The product variation is at the lowest possible disaggregated level (HS2) for bilateral trade data.

The CYH2D dataset provides information for answering the following questions: First, does the evidence support the theoretical prediction that the share of SME exports could be enhanced as a result of the development of the Internet? We seek to assess the empirical relevance in Section 4.1. Second, does the quality of the Internet also matter for the differences in the export share? Two indicators of Internet quality are introduced and the question is addressed in Section 4.2. Third, does the rise of e-commerce platforms complement or substitute traditional intermediaries? Some sectors at the HS-2 level have been identified as having a larger presence of traditional intermediaries. We exploit this variation across sectors to explore the issue in Section 4.3.

4.1. Baseline results

The results from estimating Equation (8) are reported in Table 1. We implement regressions for each of the three alternative measures of the share of exports by large exporters: the log-transformed share of the top 1% of exporters in columns (1) and (4); the log-transformed share of the top 5% of exporters in columns (2) and (5); and the log-transformed share of the top 25% of exporters in columns (3) and (6). The destination country characteristics are subsumed into the fixed effects.

The coefficient estimates on our primary variable of interest, *Internet*, are negative and highly significant for the top 5% and 25% of exporters as shown in columns (2) and (3). The results are robust to the addition of extra country attributes as reported in columns (5) and (6). This is consistent with our theoretical prediction in Case 1 that the share of exports by large exporters falls as the Internet develops, revealing the existence of forces related to the Internet that disproportionately benefit SME exporters. Column (4) of Table 1 provides the results for the share of the top 1% of exporters, which indicates that the development of the Internet has a negative but insignificant effect. Therefore, we do not find strong evidence that the export flows of the top 1% of exporters grow at a slower rate than the export flows of the rest of the exporters as the Internet develops. As mentioned, according to the definition of φ_T in this study, the smaller the *n*%, the more likely it is that φ_T is greater than φ_X. In certain circumstances, φ_T for the top 1% of exporters could be greater than φ_X (Case 2) while φ_T for the top 5% or 25% of exporters are smaller than φ_X (Case 1). This becomes a rationale for the insignificant result in column (4). Another reason that might have also contributed to the insignificant result lies in the relatively fewer observations for the top 1% of exporters. Concerning the two reasons above, the results based on the measure of the share of the top 5% or 25% of exporters are relatively more compelling for analyzing the share of SME exports.[28]

A striking difference emerges between the coefficient estimates on *Internet* and those on *Phone* . In contrast to the negative sign of the estimated coefficient on *Internet*, each regression in Table 1 gives rise to a positive and significant estimated coefficient on *Phone* , revealing that telephone development helps large exporters gain a greater share in the total exports. The empirical results therefore reveal the prominent role of the Internet in enhancing SME participation in trade, which is absent for the telephone.

[27] This is the ratio of capital services at constant 2011 national prices (*rkna*) to the number of persons engaged (*emp*).

[28] There is no consistent definition of SMEs for well understanding in SME participation in trade. (World Trade Organization, 2016)

Table 2
Share of exports by large exporters and the Internet, controlling for Internet quality. CYH2D.

VARIABLES	(1) 1%	(2) 5%	(3) 25%	(4) 1%	(5) 5%	(6) 25%
Internet	-0.117	-0.150***	-0.111***	-0.101	-0.157***	-0.126***
	(0.0976)	(0.0279)	(0.00919)	(0.0974)	(0.0279)	(0.00924)
Phone	0.304**	0.390***	0.314***	0.260*	0.374***	0.330***
	(0.145)	(0.0408)	(0.0131)	(0.148)	(0.0414)	(0.0137)
Cable	0.00217	-0.00877***	-0.00896***	0.000704	-0.00336	-0.00897***
	(0.00718)	(0.00206)	(0.000622)	(0.00735)	(0.00215)	(0.000693)
Speed				-0.0359	0.00734	0.00116
				(0.0243)	(0.00707)	(0.00234)
Disperse	1.074***	0.523***	0.191***	1.064***	0.501***	0.174***
	(0.210)	(0.0907)	(0.0240)	(0.208)	(0.0878)	(0.0231)
lnGDP	0.271	-0.471***	-0.337***	0.0187	-0.211*	-0.270***
	(0.368)	(0.100)	(0.0279)	(0.419)	(0.114)	(0.0337)
lnGDPpc	-1.044***	0.00903	0.147***	-0.825*	-0.194*	0.0705**
	(0.402)	(0.107)	(0.0304)	(0.443)	(0.115)	(0.0340)
KL	0.352	0.0821	-0.0308	0.230	0.170*	0.0288
	(0.400)	(0.0926)	(0.0235)	(0.414)	(0.0955)	(0.0250)
xr	0.0831	-0.588**	-0.227***	2.041	-0.147	-0.149
	(1.289)	(0.291)	(0.0839)	(1.600)	(0.493)	(0.164)
RD	-0.0308	0.00898	0.00964**	-0.0211	0.0244**	0.0139***
	(0.0416)	(0.0121)	(0.00386)	(0.0421)	(0.0123)	(0.00400)
Exporter-H2-Destination FEs	Y	Y	Y	Y	Y	Y
H2-Destination-Year FEs	Y	Y	Y	Y	Y	Y
Observations	16,737	108,933	357,434	16,477	103,695	332,062
R-squared	0.854	0.799	0.709	0.853	0.799	0.712

Notes: Dependent variables are the logarithm of the share of exports by the top 1%, 5% and 25% of exporters respectively. Robust standard errors clustered at the exporting country-product(HS2)-destination country level in parentheses. *** Significant at 1% level, ** Significant at 5% level, * Significant at 10% level.

The results are similar when *Phone* is excluded, as shown in Table B.2 in Appendix B.

The positive and significant coefficient estimates on *Dispersion* suggest that all else being equal, sectors in which exporters are highly dispersed are associated with relatively more exports by large exporters. Therefore, we further strengthen the empirical findings in the literature[29] about the role of *Dispersion* in studying heterogeneous firms by using cross-country data.

With respect to the other exporting country characteristics, Table 1 indicates that the share of exports controlled by the top 5% and that by the top 25% are smaller in countries with a higher level of GDP (*lnGDP*). The estimated coefficient on the exporting country's development level (*lnGDPpc*) is significantly negative for the top 1% of exporters as shown in column (4), but becomes significantly positive for the top 25% of exporters as shown in column (6). It implies that, in developed countries, the share of the top 1% of exporters is smaller, but the top 25% of exporters account for a larger share of exports. The results remain largely unchanged in Tables 2 and 3 that will be presented in the ensuing subsections, shedding some light on the relationship between size distribution of top exporters and stage of development.

4.2. Internet quality

The telecommunication infrastructure level may differ across exporting countries with the same level of Internet penetration that is proxied by the percentage of the population using the Internet, and this would matter when it comes to using e-commerce platforms for exporting. A better telecommunication infrastructure expands data transfer speed and system capacity, and is conducive to the prosperity of e-commerce platforms in the exporting country, which creates more opportunities for SMEs to export. To take into consideration the qualitative differences across exporting countries, we additionally control for two telecommunication infrastructure characteristics to provide consistency checks on the baseline estimates.

Table 3
The Internet and traditional intermediaries. CYH2D.

VARIABLES	(1) 1%	(2) 5%	(3) 25%
Internet	-0.0173	-0.124***	-0.0816***
	(0.0972)	(0.0322)	(0.0109)
Intermediaries	-0.109***	-0.133***	-0.0718***
	(0.0251)	(0.00850)	(0.00262)
Internetntermediaries	0.0410	0.0416**	0.0183***
	(0.0436)	(0.0166)	(0.00622)
Phone	0.365**	0.425***	0.282***
	(0.142)	(0.0417)	(0.0171)
Cable	0.00333	-0.00646***	-0.00629***
	(0.00719)	(0.00234)	(0.000709)
Disperse	0.903***	0.507***	0.206***
	(0.223)	(0.124)	(0.0347)
lnGDP	0.230	-0.442***	-0.251***
	(0.475)	(0.139)	(0.0341)
lnGDPpc	-0.970*	0.0124	0.0844**
	(0.510)	(0.147)	(0.0387)
KL	0.756	0.167*	-0.0335
	(0.651)	(0.0969)	(0.0241)
xr	-0.712	-0.492**	-0.147*
	(0.789)	(0.237)	(0.0867)
RD	-0.00412	0.00991	0.00474
	(0.0506)	(0.0133)	(0.00482)
Exporter-Destination FEs	Y	Y	Y
Destination-Year FEs	Y	Y	Y
Observations	36,683	160,757	444,138
R-squared	0.244	0.210	0.207

Notes: Dependent variables are the logarithm of the share of exports by the top 1%, 5% and 25% of exporters respectively. Robust standard errors clustered at the exporting countryproduct(HS2)-destination country level in parentheses. *** Significant at 1% level, ** Significant at 5% level, * Significant at 10% level.

First, we construct a measure for the development level of the submarine cable infrastructure ($Cable_{ct}$) by counting the number of submarine cables that have landed in country c in year t to capture

[29] For examples, please see HMY (2004) and Yeaple (2006).

the variation in cross-border internet connectivity, and add it to the set of explanatory variables.

This measure exploits the fact that as indicated in OECD (2019c), the bulk of data is transferred via sub-marine cables at an inter-continental level[30], making them a useful indicator of the volume of cross-border data flows. The arrival of submarine cables increases both average speeds and use of the Internet (Hjort and Poulsen, 2019)[31], which enables greater and cheaper access to information and communication. The contribution of the improved infrastructure to trade is not limited to the reduction in direct trade costs. A more intriguing role is providing better support to keep international e-commerce platforms operating smoothly and efficiently by reducing cable-related trade costs. Therefore, we expect that a higher level of *Cable* may disproportionately benefit indirect exporting and help SMEs gain a larger share of exports.

The Submarine Cable Map (https://www.submarinecablemap.com/), built by TeleGeography, records the official submarine cable system name, ready for service date and landing points for each submarine cable. It allows us to track all the submarine cables that are connected to each country with their ready for service years. For country c in year t, we add up the number of cables whose ready for service year is before or in year t. Take Egypt as an example: the value of *Cable* is 2 in 1997 as its first two submarine cables are recorded that year - FLAG Europe-Asia and Aletar. Another two cables - Taba-Aqaba and SeaMeWe-3 - became available in 1998 and in 1999 consecutively, along with which the value increases to 3 and 4 accordingly. An additional cable is not recorded until year 2005 (SeaMeWe-4). Thus, its value is kept constant at 4 from 1999 to 2004. In this way, spatial and temporal variations in *Cable* are generated.

The first three columns of Table 2 present the results. The estimated coefficients on $Cable_{ct}$ are negative and highly significant for the top 5% and 25% of exporters as shown in columns (2) and (3). It is evident that international trade transactions via e-commerce platforms can not be undertaken at all without cross-border data transfer. The results demonstrate that the share of exports by large exporters tends to shrink as more submarine cables arrive in the exporting country, which reflects the importance of indirect exporting via e-commerce platforms for SMEs.

Second, we also include the logarithm of the bandwidth data speed per subscription (*Speed*) in the specification and the data is available from Hilbert (2019). Specifically, the installed telecommunication bandwidth capacity[32] in optimally compressed kbps is divided by the amount of ICTs subscriptions in each country as an indicator of the average communication quality (Abeliansky and Hilbert, 2017). A higher value of *Speed* in the exporting country may contribute to the development of e-commerce platforms, which then helps SME exporters gain a larger share of exports.

As reported in the columns (4)-(6) of Table 2, we proceed to include *speed* and still find a negative relationship between the share of the top 5% or 25% of exporters and the development level of the submarine cable infrastructure (*Cable*), though it is not significant in column (5). However, the results do not reveal any significant effect of *Speed* on the share of exports by large firms. Considering the cross-border e-commerce platforms' need for Internet traffic to travel overseas, international transactions could be hindered by the limited volume of cross-border data transfer via submarine cables no matter how fast the local data transfer speed is. In addition, as stated in Hjort and Poulsen (2019), once plugged in, the submarine cables brought much faster speed and traffic capacities on the terrestrial network. It gives rise to the potential correlation between *Cable* and *Speed*, which might lead to the multicollinearity problem, so that the pronounced contribution of data transfer speed is not revealed.

Overall, the results in Table 2 show the negative effect of Internet quality measured by the submarine cable infrastructure on the share of exports by large firms. The results suggest that the improvement in the submarine cable infrastructure disproportionately benefits indirect exporting by SME exporters relative to direct exporting by large exporters. Notably, after controlling for the quality of the Internet, the coefficient estimates on *Internet* and *Phone* still yield a similar pattern of results to that obtained from the baseline regressions.

4.3. Interactions by the intermediary sector

Existing literature has emphasized the role played by traditional intermediaries in facilitating exports, allowing wholesalers to lower the per product fixed costs and exploit economies of scope in exporting (Bernard et al., 2015). E-commerce platforms benefit the exports of SMEs similarly as traditional intermediaries, and these platforms can be regarded as e-intermediaries. A natural question arises as to whether the effect of Internet development that we found in this work is mitigated or reinforced by the existing traditional intermediaries.

To examine their relationship, we exploit the fact that some sectors have a higher presence of traditional intermediaries than other sectors and estimate the following specification:

$$\begin{aligned} Share_{chdt} = {} & \alpha + \beta_1 Internet_{ct} + \beta_2 Intermediaries_h \\ & + \beta_3 Internet_{ct} \cdot Intermediaries_h \\ & + \beta_4 Phone_{ct} + \beta_5 Cable_{ct} + \beta_6 Dispersion_{chdt} + \gamma Z_{ct} \\ & + \lambda_{cd} + \eta_{dt} + \epsilon_{chdt}, \end{aligned} \tag{9}$$

where the sector dummy $Intermediaries_h$ takes the value of 1 if sector h at the HS 2-digit level has more traditional intermediaries and 0 otherwise. Specifically, Fernandes et al. (2016) follow Chan (2014) definition, calculated from the World Bank Enterprise Survey data, to identify sectors with a higher presence of traditional intermediaries.[33] The sectors they identified as having a greater number of traditional intermediaries are: food (HS01-24), apparel (HS41-43 and HS60-67), textiles (HS50-59), metals (HS72-83), machinery (HS84), wood (HS44-46), and miscellaneous (HS90-99). The dummy variable has the value of 1 for these sectors and 0 for other sectors. The sector dummy *Intermediaries* is interacted with *Internet* to demonstrate their interplay. The outcome variable and other explanatory variables are the same as those in Equation (8). λ_{cd} and η_{dt} indicate exporting country-destination and destination-year fixed effects, respectively.

Table 3 reports the results of the OLS regressions described by Equation (9). The effects of *Phone*, *Cable*, and *Disperse*, as estimated

[30] Submarine cables can carry far more data at far less cost than satellites. Statistics released by U.S. Federal Communications Commission indicate that satellites account for just 0.37 percent of all U.S. international capacity. https://www2.telegeography.com/submarine-cable-faqs-frequently-asked-questions

[31] Hjort and Poulsen (2019) point out two likely reasons why use of the Internet increases with submarine cable arrival. First, the technology becomes more useful to potential users. Second, the arrival of the submarine cables leads to lower prices. For their difference-in-difference analysis, they consider that each country has a specific treatment date – the date when the first submarine cable has arrived at the country's landing point and is plugged in.

[32] All telecommunication services except voice are included: the data services of fixed-line telephony-based internet in the form of dial-up, ISDN (Integrated Services Digital Network), DSL (Digital Subscriber Line), Satellite broadband, Cable modem and FTTH/B (Fiber to the Home/Business); and 2G, 2.5G, 3G and 4G mobile telephony. (Abeliansky and Hilbert, 2017)

[33] Chan (2014) computed each industry's share of total indirect exports using domestic intermediaries for each country, and presented the unweighted mean of all countries. The percentages of indirect exports for the sectors with a higher presence of traditional intermediaries are greater than 10%.

Table 4
Share of exports by large exporters and the Internet. CYH6.

VARIABLES	(1) 1%	(2) 5%	(3) 25%	(4) 1%	(5) 5%	(6) 25%
Internet	-0.418***	-0.198***	-0.0640***	-0.420***	-0.207***	-0.0712***
	(0.0714)	(0.0222)	(0.00787)	(0.0716)	(0.0222)	(0.00790)
Phone	0.835***	0.608***	0.215***	0.823***	0.648***	0.245***
	(0.140)	(0.0346)	(0.0108)	(0.145)	(0.0351)	(0.0110)
Cable				0.00187	-0.00909***	-0.00652***
				(0.00510)	(0.00155)	(0.000516)
Disperse	0.444***	0.178***	0.0434***	0.446***	0.176***	0.0429***
	(0.151)	(0.0522)	(0.00784)	(0.152)	(0.0517)	(0.00777)
lnGDP	0.000914	-0.140*	-0.0198	0.0409	-0.247***	-0.0753***
	(0.264)	(0.0747)	(0.0225)	(0.284)	(0.0776)	(0.0231)
lnGDPpc	-0.511*	-0.249***	-0.0353	-0.548*	-0.154*	0.00997
	(0.285)	(0.0776)	(0.0233)	(0.300)	(0.0796)	(0.0236)
KL	-0.195	0.0744	0.0303*	-0.175	0.0225	0.0145
	(0.301)	(0.0687)	(0.0159)	(0.308)	(0.0699)	(0.0161)
xr	-0.387	-0.0388	0.00739	-0.364	-0.0762	0.0148
	(0.564)	(0.195)	(0.0710)	(0.568)	(0.195)	(0.0710)
RD	0.0465	0.0247**	0.00928***	0.0492	0.0264***	0.0151***
	(0.0316)	(0.0101)	(0.00352)	(0.0328)	(0.0101)	(0.00349)
Exporter-H6 FEs	Y	Y	Y	Y	Y	Y
H6-Year FEs	Y	Y	Y	Y	Y	Y
Observations	23,403	119,121	317,124	23,403	119,121	317,124
R-squared	0.831	0.752	0.650	0.831	0.752	0.651

Notes: Dependent variables are the logarithm of the share of exports by the top 1%, 5% and 25% of exporters respectively. Robust standard errors clustered at the exporting country-product(HS2)-destination country level in parentheses. *** Significant at 1% level, ** Significant at 5% level, * Significant at 10% level.

using this specification, all conform to the empirical results in the previous sections.

One key finding of the present analysis is that, in sectors whose value of *Intermediaries* is 1, the enhancement effect of Internet development on the share of SME exports is mitigated, though to a modest degree. As displayed in columns (2) and (3) of Table 3, the coefficient estimate on the interaction term between *Internet* and *Intermediaries* is significantly positive based on the share of the top 5% or 25% of exporters. In each of the two columns, the coefficient on the interaction term exhibits a relatively small magnitude, such that the net effect of *Internet* stays negative. This suggests that the share of SME exports generally increases with the development of the Internet, but to a lesser extent in sectors with more traditional intermediaries.

Another finding is the confirmation of the role of traditional intermediaries in assisting the access to overseas markets for SMEs. The results in Table 3 present negative and highly significant estimated coefficients on the sector dummy (*Intermediaries*) across alternative measures of the dependent variable. As we take into consideration its interaction with *Internet*, the net effect of *Intermediaries* depends on the development level of the Internet, but remains negative.[34] This implies that the share of SME exports is larger in sectors with more traditional intermediaries, but the difference across sectors is partially offset by the diffusion of the Internet, as can be seen in the positive interaction term between *Internet* and *Intermediaries*.

In brief, we present some evidence indicating that e-intermediaries and traditional intermediaries are imperfect substitutes of each other. Intuitively, the incentive to participate in e-commerce platforms is smaller for SMEs when they can conventionally and conveniently rely on traditional intermediaries for exports. However, as the Internet develops, the reliance on traditional intermediaries is increasingly attenuated.

5. Empirical findings from the CYH6 sample

In this section, we discuss the results based on the sample at the exporting country-product(HS6)-year level (CYH6). The CYH6 sample does not allow estimations using bilateral trade data in the same way as the CYH2D sample, but the product variation is at a much more disaggregated level. Another advantage is that the estimation using the trade data aggregated at all the destinations may take into account the correlations among the destination markets via the e-commerce platforms. It can be noted that e-commerce platforms may encourage firms to export to multiple markets. That is, SMEs may be able to incur a single charge to enter multiple foreign markets via e-commerce platforms, instead of paying the fixed costs of entry to each destination market. Then, the global fixed costs could be smaller than the total fixed costs for exporting directly to each individual overseas market. The correlations among destination markets are then implicitly contained in the results.

We slightly modify Equation (8) to adapt to the sample change as follows:

$$\begin{aligned} Share_{cht} = \alpha &+ \beta_1 Internet_{ct} + \beta_2 Phone_{ct} \\ &+ \beta_3 Cable_{ct} + \beta_4 Dispersion_{cht} \\ &+ \gamma Z_{ct} + \lambda_{ch} + \eta_{ht} + \epsilon_{cht}, \end{aligned} \tag{10}$$

where $Share_{cht}$ represents the logarithm of the share of exports by large firms in industry h at the HS 6-digit level from source country c in year t. λ_{ch} and η_{ht} indicate the exporting country-product(HS6) and product(HS6)-year fixed effects, respectively.

Table 4 reports the results of the regressions as described by Equation (10). The dependent variable is the log-transformed share of the top 1% of exporters in columns (1) and (4); the log-transformed share of the top 5% of exporters in columns (2) and (5); and the log-transformed share of the top 25% of exporters in columns (3) and (6). The estimates on the variables *Internet*, *Phone*, and *Cable* are largely unchanged compared with those in Section 4. Specifically, Table 4 exhibits statistically negative estimates of *Internet* on the share of exports by large exporters in columns (1)-(6). A positive and significant coefficient estimate on *Phone* in each column provides evidence that large exporters may disproportionately gain from telephone development. In columns (4)-(6), we add an additional regressor, the submarine cable infrastructure *Cable*, and find that its estimated coefficient is negative and stays highly significant at the 1% level for the share of the top 5% or 25% of exporters. The improvement in the submarine cable system props up

[34] The value of *Internet* is less than 1.

the e-commerce platforms for their overall international businesses by reducing cable-related trade costs. This is then advantageous to the exports of SMEs.

Overall, the empirical findings support the predictions, which suggest that the share of SME exports tends to expand in countries with higher Internet development. The results also underline a larger share of SME exports attributed to the improved submarine cable infrastructure, but not to phone development. Thus, we provide added confirmation about the empirical findings from the CYH2D sample.

6. Conclusion

Can the rise of technologies based on the Internet and the remodeling of economic activity that accompanies it offer more opportunities for SMEs to participate in global markets relative to their larger competitors? This study examines the effect of the development of the Internet on the share of SMEs in total exports. Theoretically, we adopt the heterogeneous firm model of Helpman et al., 2004 to include the opportunity for firms to export indirectly to foreign markets via e-commerce platforms. Firms exporting via e-commerce platforms do not have to establish their own distribution network. They pay lower fixed export costs, but their variable trade costs become higher due to platform service fees. The most productive firms choose to export directly, while SME exporters choose to export indirectly via well-established e-commerce platforms. This sorting pattern is similar to that predicted by previous works in which firms can use wholesalers to export indirectly. However, unlike traditional intermediaries, the Internet plays an indispensable and essential role in the formation and development of e-commerce platforms. In response to the development of the Internet, the fixed costs associated with indirect exporting via e-commerce platforms fall at a higher rate than the fixed costs of direct exporting. This unparalleled reduction in fixed export costs by virtue of Internet technology allows SME exporters to account for a larger share in total exports.

Using two samples from the Exporter Dynamics Database, we find evidence supporting the theoretical prediction. Specifically, the development of the Internet in the exporting country has a significantly negative effect on the share of exports by the top 5% or 25% of exporters. The effect is weaker in sectors with a higher presence of traditional intermediaries. Improved submarine cable infrastructure in the exporting country, which is conducive to the country's development of e-commerce platforms, is shown to be associated with a lower share of exports by large exporters in the exporting country. By contrast, the development of the telephone, which is not closely associated with the operation of e-commerce platforms in the exporting country, is found to exert positive effects on the share of exports by large exporters. This implies that the reduced trading costs that are not biased toward indirect exporting via e-commerce platforms tend to reinforce the advantage that large firms have over SMEs. Overall, the evidence highlights the important role of e-commerce platforms, as enabled by the Internet, in fostering greater SME participation in a globally integrated economy. Digital technologies have been fast-accelerating. How to take full advantage of the digital revolution to help SMEs become more productive and grow is worth exploring further.

Acknowledgements

I am grateful to the editors and two anonymous referees for their helpful comments. All errors are mine.

Appendix A

A1. Proof of Equation (6)

In Case 1, we define the share of exports by large firms in total exports from country i to country j as $Share^{ij} = \frac{V_{TX}^{ij}+V_{XX}^{ij}}{V_{OX}^{ij}+V_{XX}^{ij}}$ and have:

$$Share^{ij} = \frac{\int_{\varphi_T^{ij}}^{\varphi_X^{ij}} \sigma\left(\gamma^{ij}\tau^{ij}\right)^{1-\sigma}\varphi^{\sigma-1}B^j g(\varphi)d\varphi + \int_{\varphi_X^{ij}}^{\infty} \sigma\left(\tau^{ij}\right)^{1-\sigma}\varphi^{\sigma-1}B^j g(\varphi)d\varphi}{\int_{\varphi_O^{ij}}^{\varphi_X^{ij}} \sigma\left(\gamma^{ij}\tau^{ij}\right)^{1-\sigma}\varphi^{\sigma-1}B^j g(\varphi)d\varphi + \int_{\varphi_X^{ij}}^{\infty} \sigma\left(\tau^{ij}\right)^{1-\sigma}\varphi^{\sigma-1}B^j g(\varphi)d\varphi}.$$

Under the Pareto distribution assumption, it can be rearranged as:

$$Share^{ij} = \frac{\left(\gamma^{ij}\right)^{1-\sigma}\left[\left(\varphi_X^{ij}\right)^{\sigma-k^i-1} - \left(\varphi_T^{ij}\right)^{\sigma-k^i-1}\right] - \left(\varphi_X^{ij}\right)^{\sigma-k^i-1}}{\left(\gamma^{ij}\right)^{1-\sigma}\left[\left(\varphi_X^{ij}\right)^{\sigma-k^i-1} - \left(\varphi_O^{ij}\right)^{\sigma-k^i-1}\right] - \left(\varphi_X^{ij}\right)^{\sigma-k^i-1}}.$$

Plugging in the expression of $\varphi_T^{ij} = (n\%)^{-\frac{1}{k^i}}\varphi_O^{ij}$ and Equation (4), we obtain Equation (6):

$$\begin{aligned} Share^{ij} &= \frac{\left(\gamma^{ij}\right)^{1-\sigma}\left[\left(\varphi_X^{ij}\right)^{\sigma-k^i-1} - (n\%)^{-\frac{\sigma-k^i-1}{k^i}}\left(\varphi_O^{ij}\right)^{\sigma-k^i-1}\right] - \left(\varphi_X^{ij}\right)^{\sigma-k^i-1}}{\left(\gamma^{ij}\right)^{1-\sigma}\left[\left(\varphi_X^{ij}\right)^{\sigma-k^i-1} - \left(\varphi_O^{ij}\right)^{\sigma-k^i-1}\right] - \left(\varphi_X^{ij}\right)^{\sigma-k^i-1}} \\ &= \frac{\left[1-\left(\gamma^{ij}\right)^{1-\sigma}\right]\left(\frac{\varphi_X^{ij}}{\varphi_O^{ij}}\right)^{\sigma-k^i-1} + \left(\gamma^{ij}\right)^{1-\sigma}(n\%)^{\frac{k^i-(\sigma-1)}{k^i}}}{\left[1-\left(\gamma^{ij}\right)^{1-\sigma}\right]\left(\frac{\varphi_X^{ij}}{\varphi_O^{ij}}\right)^{\sigma-k^i-1} + \left(\gamma^{ij}\right)^{1-\sigma}} \\ &= \frac{\left[1-\left(\gamma^{ij}\right)^{1-\sigma}\right]\left[\frac{f_X^{ij}-f_O^{ij}}{f_O^{ij}}\frac{1}{\left(\gamma^{ij}\right)^{\sigma-1}-1}\right]^{\frac{\sigma-k^i-1}{\sigma-1}} + \left(\gamma^{ij}\right)^{1-\sigma}(n\%)^{\frac{k^i-(\sigma-1)}{k^i}}}{\left[1-\left(\gamma^{ij}\right)^{1-\sigma}\right]\left[\frac{f_X^{ij}-f_O^{ij}}{f_O^{ij}}\frac{1}{\left(\gamma^{ij}\right)^{\sigma-1}-1}\right]^{\frac{\sigma-k^i-1}{\sigma-1}} + \left(\gamma^{ij}\right)^{1-\sigma}}. \end{aligned}$$

A2. Proof of Equation (7)

In Case 2, the share of exports by large firms in total exports from country i to country j is denoted as $Share^{ij} = \frac{V_{TT}^{ij}}{V_{OX}^{ij}+V_{XX}^{ij}}$ and we have:

$$Share^{ij} = \frac{\int_{\varphi_T^{ij}}^{\infty} \sigma\left(\tau^{ij}\right)^{1-\sigma}\varphi^{\sigma-1}B^j g(\varphi)d\varphi}{\int_{\varphi_O^{ij}}^{\varphi_X^{ij}} \sigma\left(\gamma^{ij}\tau^{ij}\right)^{1-\sigma}\varphi^{\sigma-1}B^j g(\varphi)d\varphi + \int_{\varphi_X^{ij}}^{\infty} \sigma\left(\tau^{ij}\right)^{1-\sigma}\varphi^{\sigma-1}B^j g(\varphi)d\varphi}.$$

Under the Pareto distribution assumption, it can be rearranged as:

$$Share^{ij} = \frac{\left(\varphi_T^{ij}\right)^{\sigma-k^i-1}}{\left(\varphi_X^{ij}\right)^{\sigma-k^i-1} - \left(\gamma^{ij}\right)^{1-\sigma}\left[\left(\varphi_X^{ij}\right)^{\sigma-k^i-1} - \left(\varphi_O^{ij}\right)^{\sigma-k^i-1}\right]}.$$

Plugging in the expression of $\varphi_T^{ij} = (n\%)^{-\frac{1}{k^i}}\varphi_O^{ij}$ and Equation (4), we obtain Equation (7):

$$\begin{aligned} Share^{ij} &= \frac{(n\%)^{\frac{k^i-(\sigma-1)}{k^i}}}{\left[1-\left(\gamma^{ij}\right)^{1-\sigma}\right]\left(\frac{\varphi_X^{ij}}{\varphi_O^{ij}}\right)^{\sigma-k^i-1} + \left(\gamma^{ij}\right)^{1-\sigma}} \\ &= \frac{(n\%)^{\frac{k^i-(\sigma-1)}{k^i}}}{\left[1-\left(\gamma^{ij}\right)^{1-\sigma}\right]\left[\frac{f_X^{ij}-f_O^{ij}}{f_O^{ij}}\frac{1}{\left(\gamma^{ij}\right)^{\sigma-1}-1}\right]^{-\frac{k^i-(\sigma-1)}{\sigma-1}} + \left(\gamma^{ij}\right)^{1-\sigma}}. \end{aligned}$$

Appendix B

Table B.1 and Table B.2.

Table B1
The full exporting country coverage of the dataset

Albania	Georgia	North Macedonia
Bangladesh	Guatemala	Norway
Bolivia	Guinea	Pakistan
Botswana	Iran, Islamic Rep.	Paraguay
Bulgaria	Jordan	Peru
Burkina Faso	Kenya	Portugal
Cambodia	Kuwait	Romania
Cameroon	Kyrgyz Republic	Rwanda
Chile	Lao PDR	Senegal
Colombia	Lebanon	South Africa
Costa Rica	Madagascar	Spain
Cote d'Ivoire	Malawi	Tanzania
Croatia	Mali	Thailand
Denmark	Mauritius	Timor-Leste
Dominican Republic	Mexico	Uganda
Ecuador	Morocco	Uruguay
Egypt, Arab Rep.	Myanmar	Yemen, Rep.
El Salvador	Nepal	Zambia
Ethiopia	Nicaragua	
Gabon	Niger	

Notes: Data on additional country characteristics including the capital-labor ratio (KL), exchange rate (xr), and R&D level (RD) are available only for the underlined countries. The CYH6 sample is lack of data for Egypt and Spain.

Table B2
Share of exports by large exporters and the Internet, not controlling for *Phone*. CYH2D.

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	1%	5%	25%	1%	5%	25%
Internet	-0.201**	-0.131***	-0.0827***	-0.0858	-0.111***	-0.0883***
	(0.0871)	(0.0245)	(0.00747)	(0.0959)	(0.0276)	(0.00911)
Disperse	1.202***	0.403***	0.176***	1.075***	0.527***	0.193***
	(0.221)	(0.107)	(0.0246)	(0.209)	(0.0910)	(0.0242)
lnGDP	0.390	-0.167***	-0.109***	0.0144	-0.471***	-0.281***
	(0.253)	(0.0643)	(0.0177)	(0.332)	(0.0921)	(0.0269)
lnGDPpc	-0.859***	-0.137*	0.0249	-0.754**	0.0860	0.158***
	(0.287)	(0.0719)	(0.0202)	(0.372)	(0.101)	(0.0296)
KL				0.0184	-0.0153	-0.0569**
				(0.380)	(0.0895)	(0.0228)
xr				0.409	-0.363	-0.0626
				(1.304)	(0.291)	(0.0838)
RD				-0.0375	0.00764	0.0113***
				(0.0415)	(0.0122)	(0.00390)
Exporter-H2-Destination FEs	Y	Y	Y	Y	Y	Y
H2-Destination-Year FEs	Y	Y	Y	Y	Y	Y
Observations	21,274	146,419	522,612	16,737	108,933	357,434
R-squared	0.853	0.784	0.673	0.854	0.798	0.707

Notes: Dependent variables are the logarithm of share of exports by the top 1%, 5% and 25% of exporters respectively. Robust standard errors clustered at the exporting country-product(HS2)-destination country level in parentheses. *** Significant at 1% level, ** Significant at 5% level, * Significant at 10% level.

References

Abeliansky, A.L., Hilbert, M., 2017. Digital technology and international trade: Is it the quantity of subscriptions or the quality of data speed that matters? Telecommunications Policy 41 (1), 35–48.

Ahn, J., Khandelwal, A.K., Wei, S.J., 2011. The role of intermediaries in facilitating trade. Journal of International Economics 84 (1), 73–85.

Akerman, A., 2018. A theory on the role of wholesalers in international trade based on economies of scope. Canadian Journal of Economics 51 (1), 156–185.

Akerman, A., Leuven, E., Mogstad, M., 2018. Information frictions, internet and the relationship between distance and trade (No. 1/2018). University of Oslo.

Bernard, A.B., Grazzi, M., Tomasi, C., 2015. Intermediaries in international trade: products and destinations. Review of Economics and Statistics 97 (4), 916–920.

Bernard, A.B., Jensen, J.B., Redding, S.J., Schott, P.K., 2018. Global firms. Journal of Economic Literature 56 (2), 565–619.

Blum, B.S., Claro, S., Horstmann, I., 2010. Facts and figures on intermediated trade. American Economic Review 100 (2), 419–423.

Business Finland, 2020. Global marketplaces. https://www.businessfinland.fi/495cbd/globalassets/new-pictures/consumer-business/global-marketplaces-assessment-30032020.pdf.

Chan, J., 2014. Trade Intermediation, Financial Frictions, and the Gains from Trade. Stanford University mimeo.

Cho, H., Tansuhaj, P.S., 2013. Becoming a global SME: Determinants of SMEs' decision to use e-intermediaries in export marketing. Thunderbird International Business Review 55 (5), 513–530.

Choi, C., 2010. The effect of the internet on service trade. Economics Letters 109 (2), 102–104.

Clarke, G.R., Wallsten, S.J., 2006. Has the internet increased trade? developed and developing country evidence. Economic Inquiry 44 (3), 465–484.

Crozet, M., Lalanne, G., Poncet, S., 2013. Wholesalers in international trade. European Economic Review 58, 1–17.

DeStefano, T., Kneller, R., Timmis, J., 2018. Broadband infrastructure, ICT use and firm performance: Evidence for UK firms. Journal of Economic Behavior & Organization 155, 110–139.

Felbermayr, G.J., Jung, B., 2008. Trade intermediaries, incomplete contracts, and the choice of export modes (No. 317). University of Hohenheim.

Fernandes, A.M., Freund, C., Pierola, M.D., 2016. Exporter behavior, country size and stage of development: evidence from the exporter dynamics database. Journal of Development Economics 119, 121–137.

Fernandes, A.M., Mattoo, A., Nguyen, H., Schiffbauer, M., 2019. The internet and chinese exports in the pre-ali baba era. Journal of Development Economics 138, 57–76.

Freund, C., Hufbauer, G.C., Jung, E., 2016. Enhancing Export Opportunities for Small and Medium-Sized Enterprises (No. PB16-7). PIIE.

Freund, C., Pierola, M.D., 2020. The origins and dynamics of export superstars. The World Bank Economic Review 34 (1), 28–47.

Freund, C., Weinhold, D., 2002. The internet and international trade in services. American Economic Review 92 (2), 236–240.

Freund, C., Weinhold, D., 2004. The effect of the internet on international trade. Journal of International Economics 62 (1), 171–189.

Fujii, D., Ono, Y., Saito, Y.U., 2017. Indirect exports and wholesalers: evidence from interfirm transaction network data. Japan & the World Economy 44, 35–47.

Helpman, E., Melitz, M.J., Yeaple, S.R., 2004. Export versus FDI with heterogeneous firms. American Economic Review 94 (1), 300–316.

Hilbert, M., 2019. Digital Data Divide Database (SSRN Scholarly Paper No. ID 3345756). Social Science Research Network, Rochester, NY. https://ssrn.com/abstract=3345756

Hjort, J., Poulsen, J., 2019. The arrival of fast internet and employment in africa. American Economic Review 109 (3), 1032–1079.

Huang, X., Song, X., 2019. Internet use and export upgrading: Firm-level evidence from china. Review of International Economics 27 (4), 1126–1147.

International Trade Centre, 2017. New pathways to E-commerce: A global MSME competitiveness survey. ITC, Geneva.

Kuwayama, M., 2001. E-commerce and export promotion policies for small-and medium-sized enterprises: East asian and latin american experiences. ECLAC.

Lanz, R., Lundquist, K., Mansio, G., Maurer, A., Teh, R., 2018. E-commerce and developing country-SME participation in global value chains (no. ERSD-2018-13). WTO Staff Working Paper.

Lendle, A., Olarreaga, M., 2017. Can online markets make trade more inclusive? ADBI Working Paper, No. 742, Asian Development Bank Institute (ADBI), Tokyo..

Lendle, A., Vézina, P.L., 2015. Internet technology and the extensive margin of trade: evidence from ebay in emerging economies. Review of Development Economics 19 (2), 375–386.

Lin, F., 2015. Estimating the effect of the internet on international trade. The Journal of International Trade & Economic Development 24 (3), 409–428.

Liu, L., Nath, H.K., 2013. Information and communications technology and trade in emerging market economies. Emerging Markets Finance and Trade 49 (6), 67–87.

Melitz, M.J., Redding, S.J., 2014. Heterogeneous firms and trade. In Handbook of international economics (Vol. 4, pp. 1-54). Elsevier.

OECD, 2011. The Role of Internet Intermediaries in Advancing Public Policy Objectives. OECD Publishing, Paris.

OECD, 2019a. Unpacking E-Commerce: Business Models, Trends and Policies. OECD Publishing, Paris.

OECD, 2019b. "Fostering greater SME participation in a globally integrated economy", in Strengthening SMEs and Entrepreneurship for Productivity and Inclusive Growth: OECD 2018 Ministerial Conference on SMEs. OECD Publishing, Paris.

OECD, 2019c. Measuring the Digital Transformation: A Roadmap for the Future. OECD Publishing, Paris.

Osnago, A., Tan, S.W., 2016. Disaggregating the impact of the internet on international trade. Policy Research Working Paper No.7785. The World Bank.

Ozcan, B., 2018. Information and communications technology (ICT) and international trade: evidence from turkey. Eurasian Economic Review 8 (1), 93–113.

Riker, D., 2015. The internet and product-level entry into the US market. washington, DC: Office of economics, US international trade commission.

Rodriguez-Crespo, E., Billon, M., Marco, R., 2019. Impacts of internet use on trade: New evidence for developed and developing countries. Emerging Markets Finance and Trade 1–16.

Rodriguez-Crespo, E., Marco, R., Billon, M., 2018. ICTs impacts on trade: a comparative dynamic analysis for internet, mobile phones and broadband. Asia-Pacific Journal of Accounting & Economics 1–15.

Visser, R., 2019. The effect of the internet on the margins of trade. Information Economics and Policy 46, 41–54.

Wang, M.L., Choi, C.H., 2019. How information and communication technology affect international trade: a comparative analysis of BRICS countries. Information Technology for Development 25 (3), 455–474.

World Bank Group, 2016. World Development Report 2016: Digital Dividends. World Bank, Washington, DC.

World Trade Organization (WTO), 2016. World Trade Report 2016: Levelling the Trading Field for SMEs. WTO, Geneva.

World Trade Organization (WTO), 2018. World Trade Report 2018: The Future of World Trade, How Digital Technologies are Transforming Global Commerce. WTO, Geneva.

Yadav, N., 2014. The role of internet use on international trade: Evidence from asian and sub-saharan african enterprises. Global Economy Journal 14 (2), 189–214.

Yeaple, S.R., 2006. Offshoring, foreign direct investment, and the structure of u.s. trade. Journal of the European Economic Association 4 (2-3), 602–611.