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## Regular article

# Digital connectivity and firm participation in foreign markets: An exporter-based bilateral analysis<sup>☆</sup>

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## ABSTRACT

This paper studies how the bilateral digital connectivity resulting from the deployment of telecommunications SubMarine Cable (SMC) affects firm participation in export markets. Based on a heterogeneous firm model and using an unbalanced panel of bilateral trade data across 48 countries during the period 1997–2014, we find that an SMC connection between two countries is associated with an increase in the number of bilateral exporters in developed countries, together with a reduction in the number of bilateral exporters in developing countries. This negative association between bilateral connectivity and firm participation in export markets appears to be stronger in the poorest developing areas, where firms have lower digital absorptive capacity: Middle East & North Africa and Sub-Saharan Africa. The growth in world connectivity spurred by SMCs deployment has therefore had a heterogeneous effect on firms' decision to export, pushing more firms from high-income countries to enter export markets and some incumbent exporters from lower-income countries to exit them.

## 1. Introduction

The fibre-optic SubMarine Cable (SMC) network, the cornerstone of world digital connectivity, has expanded considerably during the last two decades, spurring the digitization of information and communication contents and the digitalization of economic interactions (Tang, 2006; Weller and Woodcock, 2013).<sup>1</sup> Today, almost all coastal countries, including lower-income countries, use this infrastructure to get access to broadband Internet (Hjort and Poulsen, 2019; Cariolle, 2021; Srinivasan et al., 2013). The expansion of the cable network between and within regions has effectively shortened digital routes, significantly enhancing data transmission capacity and speed between

directly connected partners. More specifically, the arrival of a SMC between two countries or regions dramatically reduces the latency in their bilateral connectivity (Venturelli and Gabriel, 2021). For example, this has been documented when exploring the impact of the South Atlantic Cable System, which directly connected Africa (Angola) to South America (Brazil) for the first time in 2018 (Fanou et al., 2020).

Such a reduction in country-pair connectivity latency arising from a direct SMC connection enhances relationships between countries by lowering communication, search, information, and transaction costs at the bilateral level. For instance, lower latency enhances digital communications - such as email, voice, and video calls - and improves

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<sup>1</sup> Digitization refers to the "representation of information in bits [...] rather than atoms" (Goldfarb and Tucker, 2019, p.3). Digitalization refers to the increased use of digital technologies in the conduct of business and in daily life human interactions.

firms' ability to use websites to search for trading partners (Venturelli and Gabriel, 2021). Moreover, improvements in bilateral digital connections contribute to reduce customs and regulatory barriers between countries (Bellucci et al., 2023). As a result, SMC deployment has plausibly prompted the 'death of distance' between trade partners, fostering countries' participation in international trade of goods and services (Lendle et al., 2016; Goldfarb and Tucker, 2019; Akerman et al., 2022).<sup>2</sup>

From a microeconomic perspective, since firms differ in productivity and only high-productivity firms can afford additional costs to supply a given foreign market (Melitz, 2003), a reduction in trade costs between two countries due to a direct SMC connection is expected to encourage a greater number of firms to trade bilaterally. Using a heterogeneous firm model based on Melitz (2003) and Bustos (2011) with bilateral level panel data, this paper shows that the evidence is more nuanced. Under plausible parameter assumptions, the theoretical framework shows that the arrival of bilateral SMCs is likely to allow more firms to start exporting in developed countries, as a majority of firms are able to benefit from the high-speed Internet. This is because, in fact, most firms in developed countries are better poised to benefit from the broadband Internet and related information technologies, owing to a greater absorptive capacity – in terms of digital skills, R&D investment, and organizational structure – and greater proximity to urban centers and hard infrastructures (Galliano and Roux, 2008; Marsh et al., 2017). At the same time, our model predicts that, under plausible parameter configurations, on average, some exporters in developing countries are forced to exit the international market following an improved digital connection through SMCs. This outcome occurs because only high-productivity firms have the skills and organizational capacity to leverage digital technology and to tap into the Internet (Paunov and Rollo, 2016). The remaining firms might consist of non-exporters and usually small and low-productivity exporters, unable to fully exploit Internet potential.

To explore these possibilities empirically, we build a bilateral panel data set, merging bilateral trade data from the World Bank's Exporters Dynamics Database (EDD) (Fernandes et al., 2016), focusing on the number of exporting firms, with bilateral data on the maritime telecommunications infrastructure deployment from the Telegeography database. With this panel covering 48 coastal countries during the period 1997–2014, we show that after an increase in a bilateral SMC connection, the number of exporting firms increases in developed countries and declines in developing countries, especially so for countries in Middle East & North Africa (MENA), and Sub-Saharan Africa (SSA). Exogeneity tests suggest that the correlation is causal running from the bilateral digital connection to the number of exporting firms. Further explorations reveal that the negative SMC impact is stronger for low-income countries that rely more on digital connectivity (in terms of greater bandwidth capacity or share of Internet users) and have lower skill endowment (as captured by the changing share of college graduates in the population). We also show that it is the extensive margin of exports that drives the SMC impact on total export value, rather than the intensive margin (average exports per firm), especially in developing economies. Moreover, in line with the model, we find that a bilateral digital connection leads to the reallocation of market shares among exporting firms of different sizes, with heterogeneous effects in developed and developing economies. Finally, a more granular analysis conducted at the sector level shows that the results are mostly driven by high digital-intensity sectors.

<sup>2</sup> Ultimately, SMC rollout has allowed the rise and development of two-sided markets, in which an intermediary – Visa, Sony, Alphabet, Facebook, a real estate agency – allows sellers and buyers to interact at low cost (Tirole, 2017). Two-sided markets bring together supply and demand for different products and services through different types of digital platforms, with the most significant successes being Amazon in industrialized countries, Alibaba in China, or Jumia in West Africa.

Together, this paper's findings that digital connectivity is not sufficient for export success in a data-driven economy echo UNCTAD (2021)'s report, which warned of a digital divide that started during the COVID pandemic when the increase in cross-border data flows accelerated along two routes: Europe and North America, and North America and Asia. Unfortunately, tracking cross-border data flows is impossible, so, at best, this aspect of the digital divide can only be captured in firms' trade in goods and services, preferably at the bilateral level since firms in two countries that are digitally connected would be expected to trade more intensely.

To the best of our knowledge, this is the first study that emphasizes the contribution of the SMC network – the first stage in the Internet access value chain (Schumann and Kende, 2013) – to the extensive margin of exports in terms of firms at the bilateral level, using data from a large set countries. Our findings raise concerns about a growing digital divide between rich and poor nations (World Bank, 2021; UNCTAD, 2021) that could be reflected in international trade patterns and welfare. Cross-country evidence on the ICT-trade nexus focuses mainly on the linkage between aggregate bilateral exports and country-level Internet diffusion rates, showing a consistent positive association through a gravity equation approach (Freund and Weinhold, 2002, 2004; Clarke and Wallsten, 2006; Herman and Oliver, 2023). However, this literature overlooks the role of heterogeneous firms within the internet-trade linkage, and in particular, how improved access to the high-speed Internet may affect the firm's decision to supply international markets. Moreover, it does not consider the relevance of a direct SMC connection between countries in explaining firms' propensity to trade bilaterally. We fill this gap by exploiting the bilateral dimension of both digital infrastructure and trade data on the number of exporting firms, and providing also a theoretical motivation. In other words, we demonstrate that using a more demanding econometric specification that reduces the problem of omitted variable bias through a larger set of fixed effects,<sup>3</sup> we can reach different conclusions: improved Internet access may be detrimental to a firm's decision to export in developing economies.<sup>4</sup> This finding, supported by our theoretical framework, would imply smaller welfare gains from digital technology upgrading for low-income countries.

Other contributions using firm-level panel data take a single-country perspective, which is not appropriate for detecting asymmetric effects of digital connectivity across different economies. Most of these firm-level evidences focus on advanced economies – such as the United Kingdom, China, Norway and Spain – and document that a greater access to internet positively affects firm's likelihood to export (Kneller and Timmis, 2016; Fernandes et al., 2019; Akerman et al., 2022; Añón Higón and Bonvin, 2024).<sup>5</sup>

In sum, this paper complements the evidence on the ICT-trade nexus by analyzing, theoretically and empirically, how bilateral SMC connections affect firm decision to trade and country welfare, as well as whether this SMC effect differs in developed and developing economies. This is important in view of a potential growth in the digital divide between rich and poor countries mentioned above. The remainder of the paper is organized as follows. Section 2 provides background information. Section 3 sets up a motivating theoretical framework. Section 4 describes the data and empirical strategy, while the empirical results are reported in Section 5. Section 6 concludes.

<sup>3</sup> Using a similar econometric approach, Herman and Oliver (2023) show that when two countries simultaneously increase Internet use across the population (or bandwidth capacity), they also tend to increase bilateral trade. However, they neglect the Internet effect on firm's export behavior.

<sup>4</sup> Indeed, when using an empirical strategy similar to previous works, i.e. regressing the bilateral trade variable (number of exporting firms) with country- and destination-level internet variables (SMC) we find a positive linkage between internet access and trade especially in a context of developing countries, coherently with the former literature. But this empirical strategy suffers larger problems of omitted variable bias because in this strategy we can only include country-destination and year fixed effects.

<sup>5</sup> See Section 2.3 for more details.

## 2. Background and motivation

This section recaps the stages of submarine cable rollout and the associated digital interconnection process, pointing out the opportunities and challenges of digital connectivity on firm exports.

### 2.1. Submarine cables rollout and the digital interconnection process

The SMC network is the central infrastructure of the worldwide telecommunications network and the first element of the Internet access value-chain. Absent an SMC connection, a country has two costly and less efficient alternatives to get Internet access: (i) buying Internet bandwidth in a SMC-connected neighboring country, or (ii) resorting to more expensive and slower broadband satellite connectivity (at least until the arrival of Starlink which is beyond our period of analysis). SMCs therefore constitute the core infrastructure responsible for carrying the world's Internet traffic, including voice, data, and video transmissions. These cables, composed of multiple fiber-optic strands bundled within a protective sheath, are laid along the ocean floor with their endpoints buried and connected to Network Access Points (NAPs) at coastal landing stations.

The SMC industry encompasses three types of overlapping actors: cable manufacturers, cable owners and cable-laying companies. In 2023, the market had four main cable manufacturers and six main cable-laying companies.<sup>6</sup> SMCs are typically owned and operated by a consortium of telecommunication companies, each owning a portion of the cable system. The companies share the costs of installation, maintenance, and repair. For instance, the WACS cable, laid in 2012 to connect 12 countries along the path from South Africa to Portugal, shares ownership between 18 operators.<sup>7</sup> However, recently, new ownership schemes emerged in the SMC industry, with major internet content providers such as Google, Facebook, Amazon, or Microsoft, investing directly in their own SMC infrastructure.

Due to their high cost (amounting to hundreds of millions of US dollars, depending on the cable length), SMCs are interconnected at various points along their length, forming a global network of high-speed data transmission pathways. Once the main path is defined, the number of countries connected along the way will be maximized to increase business opportunities, ensure redundancy<sup>8</sup> through multiple routes, and minimize deployment costs. SMC deployment path is also subject to geological and geographic constraints, such as avoiding high-traffic maritime routes, areas subject to geological instability, or serving countries where territorial water crossing is inevitable. Specialized facilities located at coastal locations where the cables come ashore make this network operational. At these landing stations, the cables are connected to terrestrial backbone and backup networks, themselves connected to Internet eXchange Points (IXPs) and data centers. The cables finally reach end-users through last mile telecommunications infrastructures (home fiber lines or cell towers).

From 1988, with the deployment of the first fiber-optic cable TAT-8<sup>9</sup> until 2015, the total potential transmission capacity of the SMC

<sup>6</sup> The main cable manufacturers are TE Subcom (USA), Nokia's Submarine Network branch (France), NEC (Japan), and Huawei Marine Networks (China), representing 34%, 28%, 28% and 8% of the world market respectively (Morel, 2023). The main cable-laying companies are TE Subcom, Alcatel Submarine Networks Marine, Orange Marine, Global Marine Systems Ltd, E-Marine and Optic Marine.

<sup>7</sup> Altice Portugal, Angola Cables, Broadband Infracore, Camtel, Cape Verde Telecom, Congo Telecom, Liquid Intelligent Technologies, MTN, Office Congolais de Poste et Télécommunication, PCCW, Tata Communications, Telecom Namibia, Telkom South Africa, Togo Telecom, Vodacom DRC, Vodafone, Vodafone Espana, Vodafone Ghana (Submarine Cable Map, 2023).

<sup>8</sup> Redundancy is the ability to maintain a capacity for telecommunications when a shock disrupts the infrastructure by re-routing telecommunications traffic towards alternative paths.

network has multiplied by more than 400,000 (Morel, 2023). Since 2015, capacity is doubling every two years (even tripling on specific routes such as the transatlantic) to meet the increasing demand for international bandwidth (The State of the Network, 2022). Now, more than 99% of the international telecommunications between countries and continents – Internet content, phone and video calls, classified diplomatic messages – pass through SMCs (Takeshita et al., 2019). Even if the cost of providing broadband through satellite has fallen recently, the transmission capacity of the most recent satellite infrastructure remains 20 times lower than the newest deployed SMC (Morel, 2023).<sup>10</sup> Fig. 1 shows that Northern industrialized countries were the first recipients of these cables, followed by Latin America, the Middle East, and Africa since 2009 (Weller and Woodcock, 2013; Cariolle, 2021). Recently Africa has registered the highest growth rates in bandwidth capacity, growing at a 56% compound annual rate between 2016 and 2020 (The State of the Network, 2022). In sum, the deployment of SMCs has dramatically increased the worldwide telecommunications network size, capacity, and redundancy.

Since 2010, SMC infrastructure has brought together billions of Internet users, building digital bridges between almost all coastal countries, and irrigating a multi-trillion-dollar industry (Nyirenda-Jere and Biru, 2015). Fig. 2 displays the sharp growth of three connectivity indicators: (i) SMC network capacity captured by available international bandwidth per user (of which 99% is carried by SMCs); (ii) the average number of partner countries connected by cables, and (iii) a country's average share of world GDP directly reached by SMC connections, a metric of the network's connectedness (Cariolle and Da Piedade, 2023). In 2017, a country was, on average, directly connected by cables to almost 14 countries, representing on average 17% of the world GDP, and was benefiting from an average international bandwidth of 10,000 Gbps. This average capacity rose exponentially to exceed 40,000 Gbps in 2021.

This massive global deployment of broadband submarine cables (SMCs) has been a significant driver of growth for the internet economy, coinciding with greater integration of connected countries into the global economy.<sup>11</sup> The cost-reducing effects of digital technologies (Goldfarb and Tucker, 2019) are particularly significant for exporters that must process hard-to-gather information about foreign buyers, sellers, competitors, and market regulations, such as norms and standards (Rauch and Trindade, 2003; Arkolakis, 2010; Allen, 2014; Dickstein and Morales, 2018; Dasgupta and Mondria, 2018).

### 2.2. Bilateral digital connectivity and trade costs

Even prior to the advent of high-speed Internet, bilateral communication costs were key determinants of trade costs. Using 1999 data on international voice calling prices, Fink et al. (2005) show that differences in communication costs significantly influenced bilateral trade flows—particularly for differentiated products—and that these effects were independent of the volume of communication traffic between countries. So, by lowering the cost of international voice communication, the deployment of submarine cables, has played a significant role in shaping bilateral trade patterns well before bandwidth capacity and connection speed became critical for digital and data-intensive trade (Venturelli and Gabriel, 2021; Bailey et al., 2021).

<sup>9</sup> TAT-8 was the eighth transatlantic communications cable and first transatlantic fiber-optic cable, connecting the US to United Kingdom and France.

<sup>10</sup> While the Amazon's Kuiper satellite infrastructure should carry a transmission capacity of 11.2 Tb/s, Google's Dunant cable active since 2020 has a capacity of 250 Tb/s (Morel, 2023).

<sup>11</sup> Fig. B.1 illustrates this trend by highlighting a positive correlation between the number of SMCs reaching a country, and four metrics of a country's insertion in global trade: (a) exports per capita; (b) export diversification; (c) shipping connectivity; (d) backward participation in GVCs.

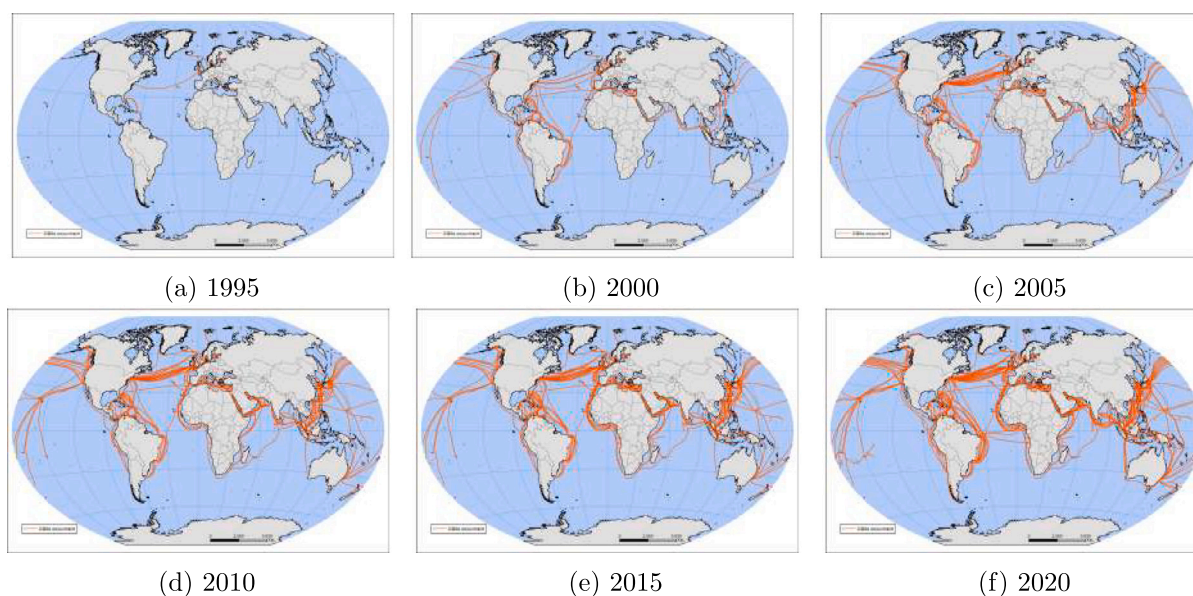


Fig. 1. SMC worldwide deployment over time. Notes: Authors' elaboration using data from the Telegeography database: <https://www.submarinecablemap.com/>.

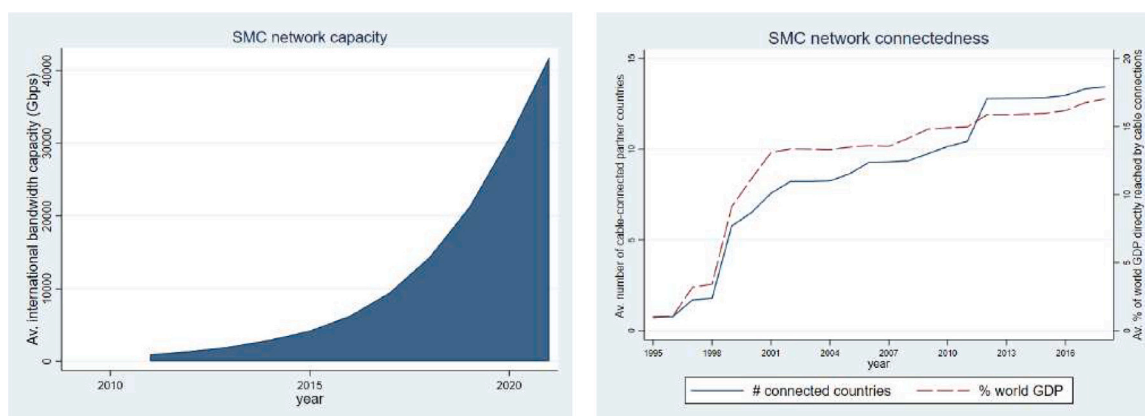


Fig. 2. SMCs rollout and the world connectivity. Notes: Authors' elaboration. Data from ITU, Telegeography, and World Development Indicators.

In the digital age, having access to low-latency connectivity is crucial for communication network performance. The most effective way to reduce latency is to shorten the distance between endpoints by laying SMCs along direct routes (Venturelli and Gabriel, 2021). For instance, Fanou et al. (2020) assess the impact of the South Atlantic Cable System (SACS)—which directly connected Africa (Angola) to South America (Brazil)—for the first time in 2018—and find that round-trip time<sup>12</sup> fell by 21% for Africa-Brazil paths and by 67% for South America-Angola routes. Similarly, Saunavaara (2025) highlights the strategic value of creating direct digital routes through the Arctic Ocean between the EU and Japan, as 90% of current traffic between Asia and Europe passes through the increasingly vulnerable Suez Canal. Establishing bilateral SMC links thus helps reduce latency, rerouting costs, and reliance on congested or insecure hubs (Morel, 2023).

Reductions in bilateral latencies, coupled with greater bandwidth, help foster trade and financial ties by lowering communication, search, information, and transaction costs. Lower latency enhances digital communications such as email, voice, and video calls—especially as users experience disruptions above 100 ms (Venturelli and Gabriel, 2021). The resulting greater ease of interaction can strengthen social

and economic ties between countries. Bailey et al. (2021) show that improved digital connections, measured using Facebook friendship data across 170 countries and 332 European regions, are associated with increased bilateral trade, especially in goods not traded on organized exchanges, where information frictions are more pronounced (Rauch, 1999).

Importantly, low latency also improves firms' ability to use websites for acquiring and retaining international customers and trade partners, as poor network performance discourages users from completing online transactions. High latency can drive users to competitors, directly affecting a firm's success (Venturelli and Gabriel, 2021).<sup>13</sup> By reducing latency, the deployment of bilateral SMCs facilitates faster financial and trade transactions across borders, including for services. Eichengreen et al. (2023) document that SMC links between currency-issuing countries and major forex trading hubs (UK, US, Japan) boost offshore foreign exchange trading. Likewise, Bellucci et al. (2023), using country-destination-sector data, show that stronger bilateral digital connectivity—measured by the lowest rate of mobile broadband subscriptions per capita among trade partners—reduces trade costs

<sup>12</sup> Round-trip time refers to the duration required for a network request to travel from its origin to its destination and back.

<sup>13</sup> According to the authors, a delay of 100 ms in website load time reduces conversion rates by up to 7%, while a delay of 6 s increases the likelihood of users abandoning the site by 106%.

for both goods and services, especially by lowering communication, information, customs, and regulatory barriers.

Moreover, bilateral connectivity supports the expansion of digital services that underpin the “servicification” of merchandise trade, enabling remote information-intensive interactions and fostering offshored and home-shored ICT, financial, transport, and logistics services.<sup>14</sup> These services—especially those sensitive to reductions in communication latency (Venturelli and Gabriel, 2021)—constitute a growing share of total services exports in developing countries and play a key role throughout goods production and delivery (Houngbonon and Mothobi, 2025; Loungani et al., 2017; Park, 2020). As production becomes increasingly fragmented across sectors, digital services facilitate the spatial unbundling of production, especially in high-tech and capital-intensive sectors requiring tight coordination (Moriset and Malecki, 2009; Baldwin, 2012; Sturgeon et al., 2017; Haltenhof et al., 2019; Baldwin and Freeman, 2022). Digital services hence support raw material exports in logistics-intensive sectors such as forestry, mining, and non-metallic minerals, which dominate exports in many low-income countries (Park, 2020).<sup>15</sup> Furthermore, digital connectivity drives ICT goods and service exports, which in turn catalyze non-ICT digital services, leading to productivity gains and spillovers (Houngbonon and Mothobi, 2025).

To summarize, a direct SMC connection between any two countries is expected to enhance the digital connectivity between them – in terms of lower latency and higher bandwidth – which in turn reduces bilateral trade costs – through enhanced communication, improved access to information, reduced transaction costs, and more efficient customs and logistics. As result, firms in one country are expected to increase their business through exporting goods and/or services to the other country, provided that firms can effectively leverage the opportunities created by increased digital connectivity.

### 2.3. Digitalization and exporters performance

Cross-country evidences have already underscored the positive contribution of internet connectivity to trade performance, using mostly bilateral data on aggregate exports and country-level internet penetration rates (Freund and Weinhold, 2004; Clarke and Wallsten, 2006; Lendle et al., 2016; Sun, 2021; Herman and Oliver, 2023). However, they overlook the role of both heterogeneous firms and direct digital connection across countries via SMC infrastructure, and therefore, how digital technology does affect firm’s decision to export bilaterally.<sup>16</sup>

More recent contributions analyze the internet-trade nexus using firm-level panel data from a single country.<sup>17</sup> Kneller and Timmis

<sup>14</sup> Baldwin and Freeman (2022) characterize “servicification” as an increasing share of services in the value-added of manufactured goods.

<sup>15</sup> Logistics intensity is defined as the ratio of logistics service inputs to total intermediate inputs. The most logistics-intensive industries include forestry and logging, mining and quarrying, wood and wood products, cork, paper and paper products, and other non-metallic mineral products.

<sup>16</sup> Some studies empirically investigate the effects of country-level Internet penetration rates on bilateral trade margins in terms of products, i.e. the number of exported products and the average exports per product (Osnago and Tan, 2016; Visser, 2019), but their analysis cannot yet adequately explore whether the adoption of more sophisticated digital technology affects firm’s decision to export (number of exporting firms) or only incumbent exporting firms (export value per firm). In fact, a change in the number of exported products does not necessarily imply a change in the number of exporting firms, and vice versa.

<sup>17</sup> Other studies analyze how a firm’s Internet use affects the firm’s export performance using repeated cross-section firm-level data from small samples in selected countries. These studies do not exploit the time variation in access to the Internet. For example, using data from Eastern European and Central Asian countries, Clarke (2008) finds positive effects of Internet access on firm’s probability to export but no significant effects on the share of exports in

(2016) follow an instrumental variable (IV) approach based on telephone network historical data to give evidence of a positive effect of broadband use on the firm-extensive margin of UK service exports. Fernandes et al. (2019) find that increasing the number of Internet users per-capita at the province level in China increases Chinese firms’ likelihood to export and export intensity. They stress that this effect is stronger when firms operate in digital-intensive industries. Using data from Spain, Añón Higón and Bonvin (2024) show a positive effect of the firm-level digital intensity on the likelihood of exporting. Closer to this study, Akerman et al. (2022) exploit the staggered rollout of local fiber-optic broadband access-points in Norway to estimate the causal effect of Internet adoption on Norwegian firms’ bilateral exports. They find that the reduction in information friction induced by Internet access expands the choice set of exporters and importers, making demand for traded products more elastic to trade costs and distance.<sup>18</sup>

Taking the perspective of a single country, potential asymmetric effects across countries remain unexplored. Thus, little is known about how bilateral digital connectivity affects firms’ ability to operate abroad and whether the effects differ between high- and low-income countries with varying levels of digital absorptive capacity.

### 3. Theoretical framework

The now standard heterogeneous firm model of trade proposed by Melitz (2003) highlights that only the most productive firms export, since they can cover the additional costs of exporting, whereas the remaining firms only supply the domestic market. Thus, following a reduction in trade costs, more firms start supplying foreign markets, while the least productive firms exit the export market due to losses in market shares. Using firm-level data from Argentina, Bustos (2011) shows that, following the removal of bilateral tariffs on the MERCOSUR trade, only high-productivity exporting firms upgraded their technology, whereas both low-productivity exporters and non-exporters did not because the fixed costs of technology upgrading were higher than the fixed costs of exporting.

This evidence suggests that the SMC arrival opens the possibility of bilateral connectivity between countries, although only the higher-productivity firms may find it profitable to cover the fixed costs of digital technology adoption. Therefore, a reduction in costs of Internet access may lead a shuffle in firm activity: sufficiently high-productivity firms poised to absorb the costs of adopting digital technologies, expand in home and export markets, while the lowest-productivity firms close down due to market share losses. As documented in World Bank (2021), digital literacy is still very limited in low (and often middle) income countries, resulting in low internet usage, with usage gaps remaining ‘stubbornly high’ across income groups.<sup>19</sup>

These usage gaps justify a distinction between firms in developed and those in developing economies. Thus, we expect that the number of exporting firms would increase in developed countries where a majority of firms are more likely to master productivity-enhancing digital technology. By contrast, in developing countries, the arrival of SMC can be beneficial only to the most productive exporting firms, and even detrimental to the other firms.<sup>20</sup>

total sales. Using firm-level data from six African countries, Hjort and Poulsen (2019) show that the arrival of SMC positively affected firm exports at the expense of domestic sales. Similar findings are documented by Hagsten and Kotnik (2017) among small-medium sized firms established at twelve advanced EU countries. Although time-varying internet data are exploited, they do not consider developing economies.

<sup>18</sup> Positive internet effects are also found on firm’s import decision in France (Malgouyres et al., 2021).

<sup>19</sup> 70 percent of respondents not using internet in low and medium countries mention lack of digital literacy as a cause while usage gaps across regions remain high (World Bank, 2021).

### 3.1. Model set up

As in Melitz (2003) and Bustos (2011), we consider heterogeneous firms competing in a monopolistic competition market. Firms decide whether to supply the international market and whether to adopt a more advanced technology, i.e. the digital technology. The “digital productivity premium” arising from the digital technology adoption is analogue to a “high technology premium” in Bustos (2011).<sup>21</sup> Therefore, we can distinguish digital producers, i.e. high-tech firms that are indexed with  $s = h$ , and non-digital producers, i.e. low-tech firms which are indexed with  $s = l$ .

Consider then two symmetric countries with  $L$  consumers in each country who provide labor at a wage rate  $w = 1$ , and have CES preferences across varieties  $\omega$ , so that the demand for a given variety is given by  $q(\omega) = p(\omega)^{-\sigma} R P^{\sigma-1}$ , where  $p(\omega)$  is the price for each variety,  $\sigma$  is the elasticity of substitution between any two varieties,  $P = \left[ \int_{\omega \in \Omega} p(\omega)^{1-\sigma} d\omega \right]^{\frac{1}{1-\sigma}}$  is the aggregate price index of the set of all available varieties  $\Omega$ , and  $R = wL$  is the aggregate revenue. Firms produce within a single monopolistic competition sector, are heterogeneous in productivity  $\varphi$ , and use labor through a linear production function to produce their varieties.

Any producer faces a fixed cost of production  $f$  and can choose to adopt digital technology, in which case  $\varphi$  increases by  $\gamma > 1$  (‘digital productivity premium’) by paying an additional fixed cost  $f_h > f$ . Therefore, the price, revenue and profit in the domestic market for the digital producer (or high-tech producer,  $s = h$ ), and non-digital producer (or low-tech producer,  $s = l$ ) are, respectively:

$$p_s(\varphi) = \frac{\sigma}{\sigma - 1} \frac{1}{\gamma^\theta \varphi}$$

$$r_s(\varphi) = p_s(\varphi)^{1-\sigma} R P^{\sigma-1}$$

$$\pi_s(\varphi) = \frac{r_s(\varphi)}{\sigma} - (f + \theta f_h)$$

where  $\theta$  equals one if  $s = h$ , and zero otherwise. Digital producers are, on average, more efficient than non-digital producers because the former are, on average, associated with higher exogenous productivity  $\varphi$  and an additional productivity premium arising from the adoption of digital technology  $\gamma$ , compared to the latter.

We also assume that if a firm wants to export, it has to face an additional fixed cost  $f_x > f$ .<sup>22</sup> As a result, exporters are, on average,

<sup>20</sup> Foster et al. (2018) report results from 264 interviews in 3 export sectors (tea, tourism, business process outsourcing) in Kenya and Rwanda. Their findings support this possibility. They document that small producers are only thinly digitally integrated in global value chains (GVCs). They conclude that improving connectivity does not benefit African firms in GVCs unless supported by complementary capacity. This possibility is captured by the distinction between firms in a high-income (developed) and a low-income (developing) economy.

<sup>21</sup> This productivity premium is supported by the empirical literature. To cite a few, conservative estimates provided by Hjort and Poulsen (2019) show that Internet speed increased by 35% in connected location following the arrival of SMCs, and that this improved internet access translated into increased productivity leading to higher employment rates. In a similar framework, Hounghonon et al. (2022) show that improved Internet access enabled by SMC laying in Africa positively influenced both firm’s process and product innovation, enhancing the likelihood of firms engaging in such innovations by 20 and 12 percentage points, respectively. Interestingly, this productivity premium appears to increase with the number of Internet adopters. In fact, Cariolle and Le Goff (2023) study spatial spillover effects of SMC arrival on manufacturing firms in developing countries, and show that a 10 percentage-point increase in locations’ share of firms using email led to a 40% increase in manufacturing firm’s labor productivity, and that spillover effects were partly driven by outward-oriented firms.

<sup>22</sup> Since our focus is on the impact of the arrival of new digital technology, we assume duty-free trade, i.e. we do not consider changes in trade policy.

more productive than non-exporters because the former are, on average, associated with higher exogenous productivity  $\varphi$ . Firms pay the sunk fixed cost  $f_e$  to enter the market and draw their productivity from a known Pareto cumulative distribution function  $G(\varphi) = 1 - \varphi^{-k}$ , where  $k > \sigma - 1$ . Then, they decide whether to stay in the market or to exit immediately.

To sort firms within a sector, we plausibly consider two cases. In the developed economy case ( $DC = 0$ ), digital literacy and associated skills result in low fixed costs for the adoption of digital technology. In the developing economy case ( $DC = 1$ ), firms need to invest in improving the digital literacy of their workers and managers. These assumptions result in the two configurations of the fixed cost of digital technology adoption  $f_h$  and the fixed cost of exporting  $f_x$  across the two cases illustrated in the figures below.

**The developed economy case.** For a developed economy ( $DC = 0$ ), the fixed cost of digital technology is relatively low ( $f < f_h < f_x$ ). It is then profitable for the majority of firms to use digital technology, including all exporting firms. This gives the following profit conditions for selling in the domestic ( $d$ ) and export ( $x$ ) markets:

$$\pi_l^d(\varphi_l^d) = 0 \iff \frac{r_l^d(\varphi_l^d)}{\sigma} - f = 0 \tag{1}$$

$$\pi_h^d(\varphi_h^d) = \pi_l^d(\varphi_h^d) \iff \frac{r_h^d(\varphi_h^d)}{\sigma} - (f + f_h) = \frac{r_l^d(\varphi_h^d)}{\sigma} - f \tag{2}$$

$$\pi_h^{d+x}(\varphi_h^x) = \pi_h^d(\varphi_h^x) \iff \frac{r_h^{d+x}(\varphi_h^x)}{\sigma} - (f + f_h + f_x) = \frac{r_h^d(\varphi_h^x)}{\sigma} - (f + f_h) \tag{3}$$

where  $\varphi_l^d$  is the survival cutoff, i.e. the minimum level of productivity required to survive in the domestic market,  $\varphi_h^d$  is the digital technology cutoff, i.e. the minimum level of productivity required to adopt the digital technology, and  $\varphi_h^x$  is the export cutoff, i.e. the minimum level of productivity required to supply the foreign market.

The equilibrium condition is obtained from the free entry condition  $\psi_d \frac{\bar{\pi}}{\delta} = f_e$ , where  $\psi_d = 1 - G(\varphi_l^d)$  is the probability of survival,  $\bar{\pi}$  is the per-period expected profit of surviving firms,  $\delta$  is a per-period exogenous probability of exit. Notice that  $\varphi_l^d < \varphi_h^d < \varphi_h^x$  only if the fixed cost of exporting  $f_x$  is sufficiently higher than the fixed cost of digital technology  $f_h$ ,<sup>23</sup> which in turn is higher enough than the fixed cost of production  $f$ .<sup>24</sup>

Fig. 3 depicts the three possible profits as function of firm productivity and shows how the firms sort into three different groups in this equilibrium: the least productive firms that focus only on the domestic market without adopting a digital technology ( $\varphi_l^d < \varphi < \varphi_h^d$ ), the most productive firms that are also involved in export activities with a digital technology ( $\varphi > \varphi_h^x$ ), and the medium-productivity firms, which adopt digital technology without exporting ( $\varphi_l^d < \varphi < \varphi_h^d$ ). Therefore, it can be shown that an increase in digital productivity premium  $\gamma$  arising from the arrival of SMCs implies a reduction in the digital technology cutoff  $\varphi_h^d$ , and an increase in the survival cutoff  $\varphi_l^d$ , so that the most productive non-exporters start using the digital technology and the least productive firms exit the market. At the same time, it leads to a decrease in the export cutoff  $\varphi_h^x$ , which would imply the entry of new firms in the export market and, therefore, a reallocation of the export market shares from high- to low-productivity firms.

**The developing economy case.** For a developing economy ( $DC = 1$ ) where the fixed cost of digital technology adoption is relatively high

This means that firms earn a lower export profit than a domestic profit, even though they have the same price and revenue in the foreign market as they do in the home market.

<sup>23</sup>  $f_x > \left( \frac{\gamma^{\sigma-1}}{\gamma^{\sigma-1}-1} \right) f_h$ .

<sup>24</sup>  $f_h > (\gamma^{\sigma-1} - 1)f$ .

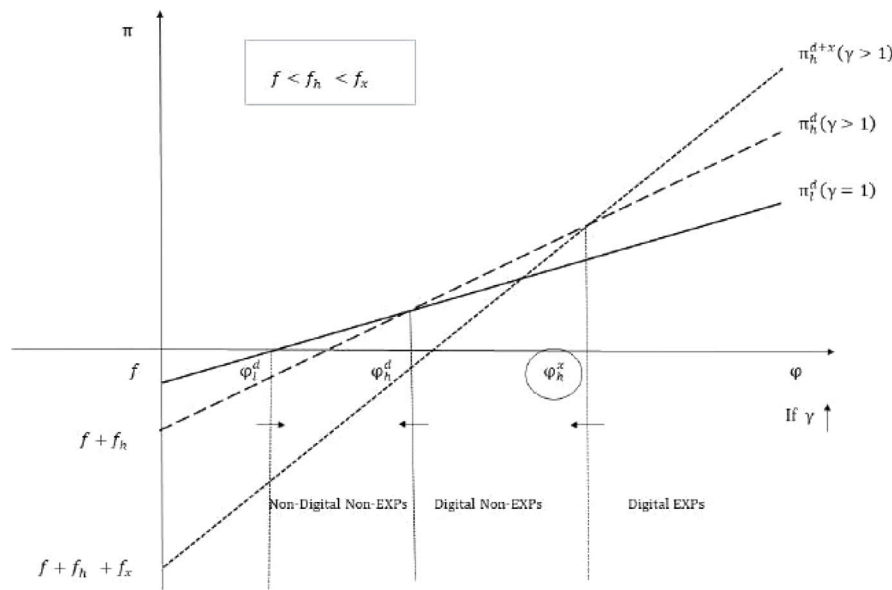


Fig. 3. The developed economy case.

Notes: Firm profit  $\pi$  is on the vertical axis and (exogenous) firm productivity  $\varphi$  is on the horizontal axis. Profit lines:  $\pi_l^d$  refers to the domestic profit of non-digital firms (i.e. without the digital productivity premium ( $\gamma = 1$ )) that face only the fixed cost of production  $f$ ;  $\pi_h^d$  refers to the domestic profit of digital firms (i.e. associated with the digital productivity premium ( $\gamma > 1$ )) that also face the fixed cost of digital technology  $f_h$ ;  $\pi_h^{d+x}$  refers to the domestic and foreign profit of digital firms (i.e. associated with the digital productivity premium ( $\gamma > 1$ )) that also face the fixed cost of exporting  $f_x$ . Productivity cutoffs:  $\varphi_l^d$  is the survival cutoff, i.e. the minimum level of productivity required to survive in the domestic market,  $\varphi_l^d$  is the digital technology cutoff, i.e. the minimum level of productivity required to adopt the digital technology,  $\varphi_h^x$  is the export cutoff, i.e. the minimum level of productivity required to supply the foreign market.

( $f < f_x < f_h$ ), fewer firms adopt a digital technology, i.e. only the most productive exporters. The corresponding profit conditions are:

$$\pi_l^d(\varphi_l^d) = 0 \iff \frac{r_l^d(\varphi_l^d)}{\sigma} - f = 0 \tag{4}$$

$$\pi_l^{d+x}(\varphi_l^x) = \pi_l^d(\varphi_l^x) \iff \frac{r_l^{d+x}(\varphi_l^x)}{\sigma} - (f + f_x) = \frac{r_l^d(\varphi_l^x)}{\sigma} - f \tag{5}$$

$$\pi_h^{d+x}(\varphi_h^x) = \pi_l^{d+x}(\varphi_h^x) \iff \frac{r_h^{d+x}(\varphi_h^x)}{\sigma} - (f + f_x + f_h) = \frac{r_l^{d+x}(\varphi_h^x)}{\sigma} - (f + f_x) \tag{6}$$

where  $\varphi_l^d$  is the survival cutoff,  $\varphi_l^x$  is the export cutoff, and  $\varphi_h^x$  is the digital technology cutoff. As before, the free entry condition  $\psi_d \frac{\pi}{\delta} = f_e$  determines the equilibrium. Note that  $\varphi_l^d < \varphi_l^x < \varphi_h^x$  only if the fixed cost of digital technology  $f_h$  is sufficiently higher than the fixed cost of exporting  $f_x$ ,<sup>25</sup> which in turn is higher enough than the fixed cost of production  $f$ .<sup>26</sup>

Fig. 4 shows the three possible profits as function of firm productivity, therefore, how the firms sort into three different groups in this equilibrium: the least productive firms that supply only the domestic market without a digital technology ( $\varphi_l^d < \varphi < \varphi_l^x$ ), the most productive firms that are involved in exporting with a digital technology ( $\varphi > \varphi_h^x$ ), and medium-productivity firms, which export without adopting a digital technology ( $\varphi_l^x < \varphi < \varphi_h^x$ ).<sup>27</sup> It can be demonstrated that an increase in the digital productivity premium  $\gamma$  resulting from the

arrival of SMCs leads to a decrease in the digital technology cutoff  $\varphi_h^x$ , and an increase in the survival cutoff  $\varphi_l^d$ , so that exporters with sufficiently high productivity start using digital technology, and the least productive firms exit the market. At the same time, it leads to an increase in the export cutoff  $\varphi_l^x$ , which entails the exit of the least productive exporters from the international market, as well as the reallocation of the export market shares from low- to high-productivity firms.

### 3.2. Adjustment of the number of exporting firms to the arrival of SMCs

In this set-up, it can be shown that subsequent to a digital productivity gain arising from the arrival of a bilateral SMC – i.e. an increase in  $\gamma$  resulting from lower communication and information search costs permitted by higher internet speed and bandwidth (Dickstein and Morales, 2018) – the number of exporting firms  $N_x = \psi_x N$  in developed countries ( $DC = 0$ ) increases due to an increase in the probability of exporting  $\psi_x = [1 - G(\varphi_h^x)]/[1 - G(\varphi_l^d)]$  and despite a decline in the number of surviving firms  $N$ . Conversely, the number of exporting firms  $N_x = \psi_x N$  in developing countries ( $DC = 1$ ) declines subsequent to the arrival of a bilateral SMC, through a fall in the number of surviving firms  $N$  and despite the probability of exporting  $\psi_x = [1 - G(\varphi_l^x)]/[1 - G(\varphi_l^d)]$  remains unchanged.<sup>28</sup> Further discussion is reported in Appendix A.

**Testable hypothesis.** Following the arrival of SMCs at the bilateral level, the number of exporting firms increases in developed countries and declines in developing countries.

<sup>25</sup>  $f_h > 2(\gamma^{\sigma-1} - 1)f_x$ .

<sup>26</sup>  $f_x > f$ .

<sup>27</sup> Note that this case is similar to Bustos (2011)'s study of the impact of trade liberalization on technology upgrading of Argentinian exporters. She shows theoretically and empirically that a bilateral tariff cut induces more firms to adopt the new technology.

<sup>28</sup> The number of surviving firms  $N$  and the number of exporting firms  $N_x$  decline proportionally because of the increase in  $\gamma$ , leaving the fraction of exporters  $\psi_x$  unchanged.

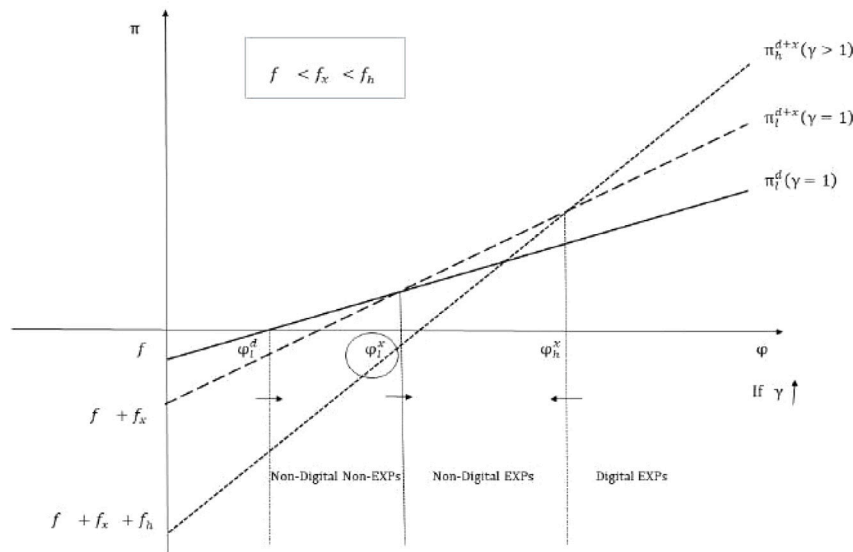


Fig. 4. The developing economy case.

Notes: Firm profit  $\pi$  is on the vertical axis and (exogenous) firm productivity  $\phi$  is on the horizontal axis. Profit lines:  $\pi_i^d$  refers to the domestic profit of non-digital firms (i.e. without the digital productivity premium ( $\gamma = 1$ )) that face only the fixed cost of production  $f$ ;  $\pi_i^{d+x}$  refers to the domestic and foreign profit of non-digital firms (i.e. without the digital productivity premium ( $\gamma = 1$ )) that also face the fixed cost of exporting  $f_x$ ;  $\pi_i^{d+x}$  refers to the domestic and foreign profit of digital firms (i.e. associated with the digital productivity premium ( $\gamma > 1$ )) that also face the fixed cost of digital technology  $f_h$ . Productivity cutoffs:  $\phi_i^d$  is the survival cutoff, i.e. the minimum level of productivity required to survive in the domestic market,  $\phi_i^x$  is the export cutoff, i.e. the minimum level of productivity required to supply the foreign market, and  $\phi_h^x$  is the digital technology cutoff i.e. the minimum level of productivity required to adopt the digital technology.

### 3.3. Welfare analysis

In our set-up, as in Melitz (2003), welfare  $W$  can be written in terms of the survival productivity cutoff  $\phi_i^d$  and parameters

$$W = \left( \frac{L}{\sigma f} \right)^{\frac{1}{\sigma-1}} \frac{\sigma-1}{\sigma} \phi_i^d$$

In each case, it can be shown that an increase in digital productivity gain arising from the arrival of a bilateral SMC (i.e. an increase in  $\gamma$ ) leads to an increase in survival cutoff  $\phi_i^d$ , and therefore an increase in welfare  $W$ . As in the heterogeneous firm literature (e.g. Melitz and Redding, 2015), we compare welfare after using digital technology at time 1 with welfare without any digital technology at time 0, as follows

$$WG = \frac{W^1}{W^0} = \left( \frac{f + \psi_x^1 f_x + \psi_h^1 f_h}{f + \psi_x^0 f_x} \right)^{\frac{1}{k}}$$

where  $\psi_x^0$  is the probability of exporting at time 0, while  $\psi_x^1$  and  $\psi_h^1$  are, respectively, the probability of exporting and the probability of digital technology adoption at time 1. In each case contemplated in our model, countries obtain welfare gains from digital technology adoption given that  $WG > 1$ .<sup>29</sup> This means that the within-firm productivity gains for firms adopting digital technology jointly with productivity gains from resource reallocation across firms are larger than the potential welfare losses from variety. As shown in Appendix, welfare gains in the developed economy case ( $DC = 0$ ) are larger than those in the developing economy case ( $DC = 1$ ) if the fixed cost of digital technology adoption for firms in the developing country case is sufficiently higher compared to the developed economy setting. This occurs because the fraction of firms obtaining productivity gains from digital technology adoption is smaller and welfare losses from variety are larger in the developing economy case.

<sup>29</sup> Notice that in absence of digital technology, developed economy case is identical to developing economy case, assuming that all parameters are similar. The two cases diverge when considering digital technology adoption, which is associated with a different fixed cost across the two cases.

## 4. Data and empirical strategy

### 4.1. Data and descriptive statistics

We use bilateral trade data from the World Bank’s Exporter Dynamics Database (EDD), which contains aggregated measures on export characteristics from 68 countries in different periods, ranging between 1997 and 2014 (Cebeci et al., 2012; Fernandes et al., 2016),<sup>30</sup> by focusing mainly on the number of exporting firms at the bilateral level. This database, built by the World Bank using detailed trade transaction data from national custom offices, covers the universe of formal exporting firms within each country. To have a complete database of bilateral trade relationships that includes zero trade flows, we first create all possible country-destination-year combinations for each country over its available period. Next, we replace all missing information with zeros, assuming that all non-reported information is zero.<sup>31</sup> We also use bilateral data on the maritime telecommunications infrastructure deployment across 171 countries over 1990–2018 drawn from Telegeography database, by first considering the activation time of a bilateral digital connection through SMCs, and then using the number of SMCs connecting one country to another.

By merging the two datasets above, we build a final unbalanced panel of matched export and Internet data at the bilateral level for 48 coastal countries during the period 1997–2014 which saw the share of cable-connected countries increase from some 40% to more than 90%.<sup>32</sup>

<sup>30</sup> The number of available years changes across exporting countries in EDD database, and ranges from 1 year (Sao Tomé, Sri Lanka) to 18 years (Brazil, Norway) in our final sample. We did not exclude *a priori* any country depending on the number of available years to avoid any potential problem of sample selection bias. However, as robustness check, we run our baseline regression without countries with a short period available, i.e. four or less years, and the results (available upon request) remain similar.

<sup>31</sup> For robustness, we run our main specification without replacing missing values with zeros and the results, available upon request, are consistent with the baseline results in Table 2, column 2.

<sup>32</sup> Over a total of 172 coastal countries. Some countries from World Bank’s EDD data have been dropped as they are not included in the SMC data, mostly because they are landlocked countries.

**Table 1**  
Country-level average number of exporting firms across destinations in 2009.

Country	Region	Av. # firms	Country	Region	Av. # firms	Country	Region	Av. # firms
DEU	OTHERS	3783	EGY	MENA	110	URY	LAC	30
ESP	OTHERS	1780	IRN	MENA	105	MUS	SSA	29
TUR	ECA	922	PER	LAC	103	CIV	SSA	22
BEL	OTHERS	723	LBN	MENA	83	TZA	SSA	19
BRA	LAC	500	MAR	MENA	75	KHM	EAP	17
DNK	OTHERS	467	EST	OTHERS	72	MDG	SSA	17
MEX	LAC	404	ECU	LAC	66	NIC	LAC	14
ZAF	SSA	348	HRV	ECA	58	CMR	SSA	14
PRT	OTHERS	343	GTM	LAC	54	ALB	ECA	13
NOR	OTHERS	323	CRI	LAC	52	SEN	SSA	13
PAK	SA	279	KEN	SSA	52	GEO	ECA	10
BGD	SA	155	JOR	MENA	37	YEM	MENA	8
COL	LAC	149	KWT	OTHERS	37	GIN	SSA	3
CHL	LAC	135	DOM	LAC	33			

Notes: Seven countries are out because the available period is prior to 2009 (SWE, BGR and GAB) or subsequent to 2009 (MMR, LKA, THA and STP). See Table B.1 for the full names of the countries.

Table B.1 in Appendix shows the distribution of observations across countries and regions. Three-quarters of our sample (shares in parentheses) concern developing countries<sup>33</sup>: Latin America & the Caribbean (LAC) (30.4%), Sub-Saharan Africa (SSA) (20.4%), Middle East & North Africa (MENA) (9.5%), Europe & Central Asia (ECA) (9.3%), South Asia (SA) (4.3%) and East Asia & the Pacific (EAP) (3.5%). The rest of the sample (OTHERS) (22.6%) consists of high-income countries located mainly in Western Europe.<sup>34</sup>

By focusing on the most common year across countries, i.e. 2009, Table 1 displays a large country heterogeneity in the average number of exporting firms across destinations (from 3 in Guinea to 3783 in Germany) and within regions (from 14 in Nicaragua to 500 in Brazil in LAC, and from 3 in Guinea to 348 in South Africa within SSA). Looking at the time evolution of the average number of exporting firms across destinations for each country in Figs. B.2–B.7, we observe that this number is increasing within ECA and SA, slightly increasing or stable within OTHERS, and decreasing in EAP (except for Cambodia, where the trend is increasing after an initial decline). Moreover, it is fluctuating along a constant trend in SSA (except for Kenya and Senegal, where the trend is increasing), and more heterogeneous within MENA.

Fig. 5 displays the time evolution of metrics of SMC’s network capacity (top graphs)<sup>35</sup> and connectivity (bottom graph)<sup>36</sup> across regions. While high-income countries (OTHERS) display a markedly higher SMC network’s absolute and relative capacity than other countries, SSA shows a rapid growth in absolute SMC network capacity, catching up to the rest of the world in terms of relative capacity by the end of the sample period. Looking at the SMC network’s connectivity, SSA and ECA countries remain poorly connected to the world economy, by reaching on average 10% of the world GDP, compared to 30%–40% in high-income countries and other Asian regions.

<sup>33</sup> Exporting countries are classified as developed and developing economies following (the Appendix of) Cebeci et al. (2012) which provides information on the EDD data, and groups developing/emerging countries in different regional groups, while keeping advanced countries within a single group, named “other countries”.

<sup>34</sup> Kuwait, a high-income country located in the Middle East, is the only non-European country. When excluding this country from the analysis, our baseline findings remain unchanged (results available upon request).

<sup>35</sup> SMC network’s absolute capacity is measured by the regional average number of SMCs by country (top-left graph), while its relative capacity is measured by the ratio of the regional population average over the regional average number of SMCs (top-right graph, the lower the ratio the greater the relative capacity).

<sup>36</sup> The SMC network’s outreach is measured by the average cumulative share of world GDP reached by direct cable connections.

#### 4.2. Econometric model

Our empirical analysis aims to explore how direct SMC connections affect firm’s export participation at the bilateral level, and in particular, whether the SMC effect is different between developed and developing economies, as highlighted by our theoretical predictions. We estimate the following baseline specification, which can be derived from the structural gravity equation through log-linearization (Anderson and Van Wincoop, 2003; Helpman et al., 2008):

$$\ln N_{exporters_{cdt}} = \beta_1 SMC_{cdt-1} + \beta_2 SMC_{cdt-1} \times DC_c + \alpha_{cd} + \alpha_{ct} + \alpha_{dt} + \varepsilon_{cdt} \tag{7}$$

where  $N_{exporters_{cdt}}$  is the number of firms in country  $c$  exporting to destination  $d$  in year  $t$ ; and  $SMC_{cdt-1}$  is our main variable of interest, i.e. a dummy variable taking the value one if country  $c$  is directly connected through at least one SMC to a given destination  $d$  in year  $t - 1$ , and zero otherwise; while  $DC_c$  is a dummy variable taking the value one if country  $c$  is a developing economy and zero otherwise. From the discussion in Section 3.2, we expect that  $\beta_1 > 0$  and  $\beta_2 < 0$ , i.e. following the arrival of SMCs, firm participation in export markets, on average, increases in developed countries and decreases in developing countries. Table B.2 shows the summary statistics of the main variables.

The specification also includes country-destination pair fixed effects ( $\alpha_{cd}$ ) to account for time-invariant characteristics at the bilateral level (e.g. distance), as well as country-year and destination-year fixed effects ( $\alpha_{ct}$ ,  $\alpha_{dt}$ ) to control for time-varying characteristics at either country or destination level (e.g. GDP and multilateral resistance terms in both trading partners). Due to the inclusion of a large set of fixed effects, the R-squared is expected to be very high — a pattern commonly observed in the gravity literature. Standard errors are corrected for clustering at the bilateral level. Since using a linear regression technique to estimate (7) might be inconsistent in the presence of heteroscedasticity, and does not take into account zero trade values (Silva and Tenreyro, 2006), we use the Poisson pseudo-maximum likelihood (PPML) model<sup>37</sup> considering the same high dimension of fixed-effects as in most recent studies (e.g. Larch et al., 2019):

$$N_{exporters_{cdt}} = \exp(\beta_1 SMC_{cdt-1} + \beta_2 SMC_{cdt-1} \times DC_c + \alpha_{cd} + \alpha_{ct} + \alpha_{dt}) + v_{cdt} \tag{8}$$

<sup>37</sup> Using  $\ln(1 + N_{exporters_{cdt}})$  to account for zero-trade values in our dependent variable prevents interpreting the results as (semi-) elasticities (Chen and Roth, 2024). For this reason, we used  $\ln(N_{exporters_{cdt}})$  in the OLS specification, and then  $N_{exporters_{cdt}}$  in the PPML specification to consider zero-trade values.

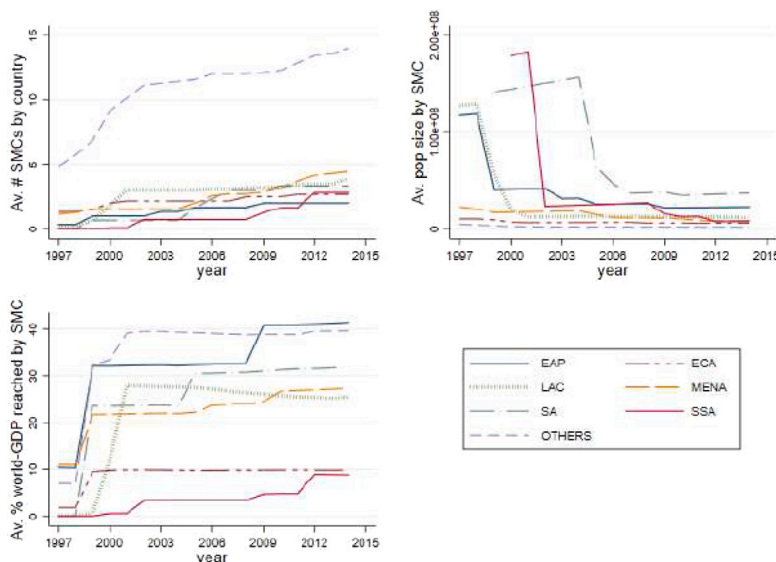


Fig. 5. SMC network and regional connectivity through time, 1997–2014.

Notes: Authors’ computation, based on the baseline estimation sample. Raw data from Telegeography and World Development Indicators. EAP = East Asia & the Pacific; ECA = Europe & Central Asia; LAC = Latin America & the Caribbean; MENA = Middle East & North Africa; OTHERS = Developed Economies; SA = South Asia; SSA = Sub-Saharan Africa.

Table 2  
Bilateral-level linkage between number of exporting firms and SMC arrival.

Dep. Var: $N_{exporters_{cdt}}$	(1)	(2)	(3)	(4)
$SMC_{cdt-1}$	0.0910** (0.0420)	0.0879*** (0.0298)	0.0868*** (0.0297)	0.0833*** (0.0273)
$SMC_{cdt-1} \times DC_c$	-0.174*** (0.0514)	-0.146*** (0.0382)		-0.136*** (0.0384)
<i>Regions of origin</i>				
$SMC_{cdt-1} \times ECA_c$			0.0662 (0.160)	
$SMC_{cdt-1} \times LAC_c$			-0.126*** (0.0466)	
$SMC_{cdt-1} \times MENA_c$			-0.187*** (0.0517)	
$SMC_{cdt-1} \times SA_c$			-0.115** (0.0543)	
$SMC_{cdt-1} \times SSA_c$			-0.166*** (0.0547)	
<i>Destination’s development stage</i>				
$SMC_{cdt-1} \times DC_d$				0.0192 (0.0721)
$SMC_{cdt-1} \times DC_c * DC_d$				-0.0285 (0.0776)
Country-Destination FE	YES	YES	YES	YES
Country-Year FE	YES	YES	YES	YES
Destination-Year FE	YES	YES	YES	YES
Observations	53,963	65,272	65,272	65,272
(Pseudo) $R^2$	0.978	0.993	0.993	0.993

Notes: Unbalanced panel of country-destination pairs. Column 1 is based on OLS model, where standard errors are corrected for clustering at the bilateral level. Columns 2–4 are based on PPML model, where standard errors are corrected for multi-way clustering. Variables:  $N_{exporters_{cdt}}$  is the number of firms in country  $c$  exporting to destination  $d$  in year  $t$ ;  $SMC_{cdt-1}$  is a dummy variable taking value one if country  $c$  is directly connected through at least one SMC to a given destination  $d$  in year  $t - 1$  and zero otherwise;  $DC_c$  is a dummy variable taking value one if country  $c$  is a developing economy and zero otherwise;  $DC_d$  is a dummy variable taking value one if destination  $d$  is a developing economy and zero otherwise;  $ECA_c$ ,  $LAC_c$ ,  $MENA_c$ ,  $SA_c$ , and  $SSA_c$  are dummy variables that take value one (and zero otherwise) if exporting firms are respectively located at Europe & Central Asia, Latin America & the Caribbean, Middle East & North Africa, South Asia, and Sub-Saharan Africa. \*, \*\*, \*\*\* respectively denote the 10%, 5%, 1% significance levels.

Since trade flows involving small and/or poor countries turn out to be more heteroscedastic than those involving other countries (Larch

Table 3  
Endogeneity issues.

Dep. Var: $N_{exporters_{cdt}}$	(1)	(2)
$SMC_{cdt-1}$	0.0758*** (0.0224)	0.0519* (0.0294)
$SMC_{cdt-1} \times DC_c$	-0.0563* (0.0322)	-0.124*** (0.0377)
$SMC_{cdt}$		0.0350 (0.0305)
$SMC_{cdt} \times DC_c$		-0.00768 (0.0354)
$SMC_{cdt+1}$		0.0365 (0.0305)
$SMC_{cdt+1} \times DC_c$		-0.0401 (0.0419)
Country-Destination FE	YES	YES
Country-Year FE	YES	YES
Destination-Year FE	YES	YES
Country-Destination specific trend	YES	NO
Observations	65,272	65,272
Pseudo $R^2$	0.995	0.993

Notes: Unbalanced panel of country-destination pairs. PPML model, where standard errors are corrected for multi-way clustering. Variables:  $N_{exporters_{cdt}}$  is the number of firms in country  $c$  exporting to destination  $d$  in year  $t$ ;  $SMC_{cdt-1}$ ,  $SMC_{cdt}$  and  $SMC_{cdt+1}$  are dummy variables taking value one (and zero otherwise) if country  $c$  is directly connected through at least one SMC to a given destination  $d$  in year  $t - 1$ ,  $t$  and  $t + 1$  respectively;  $DC_c$  is a dummy variable taking value one if country  $c$  is a developing economy and zero otherwise. \*, \*\*, \*\*\* respectively denote the 10%, 5%, 1% significance levels.

et al., 2019) and that our sample covers mainly developing economies, we expect differences between the PPML and OLS estimates. Since standard errors should allow for simultaneous correlations across all three dimensions of the panel ( $c, d, t$ ) we also correct standard errors for multi-way clustering, which nests the typical practice of assuming that standard errors are only clustered within country-destination pair over time (Larch et al., 2019). Correcting for multi-way clustering should allow for simultaneous correlations across all the panel dimensions, given that there is the possibility of having a cross-sectional dependence within time periods, in addition to auto-correlations across time within countries (Cameron et al., 2011). In the context of the panel-data gravity model, this means that we need to account for cross-sectional dependence between exporters and between importers - due to the

joint determination of all countries' prices in general equilibrium - in addition to time interdependence because of inertia in bilateral trade relationships (Egger and Tarlea, 2015).

## 5. Results

### 5.1. Main findings

**The SMC impact on the extensive margin of exports.** Table 2 reports estimates of Eqs. (7) and (8) in columns 1 (OLS) and 2 (PPML), respectively. Column 1 highlights that following a bilateral direct connection through the SMC, the number of exporting firms increases by 9.5% in developed economies and declines by 8.0% in developing countries.<sup>38</sup> These findings are confirmed in column 2, although with a slightly smaller magnitude (by 9.2% and 5.6%, respectively). For reasons mentioned above, we stick to PPML estimates for the rest of the paper.<sup>39</sup> In column 3, we explore the potential heterogeneous effects of SMC bilateral deployment across geographic areas. While the number of exporting firms increases in ECA following a bilateral SMC connection, it continues to decline in other developing regions, particularly in MENA and SSA. These results suggest that exporting firms in areas concentrating lower-middle and low-income countries lose from the bilateral SMC connection. Finally, by interacting our main explanatory variables in Eq. (8) with a dummy variable that takes the value one if the destination  $d$  is a developing country and zero otherwise ( $DC_d$ ) in column 4, we show that the effects of improved connectivity on the number of exporting firms do not depend on whether the trading partners are similar or dissimilar in their development stage.

Overall, this first set of results supports the prediction that bilateral SMC deployment contributes to increase the number of exporting firms in developed countries but to reduce it in developing countries. Among developing economies, this adverse effect is more striking in countries in the SSA and MENA regions but does not seem to be related to export destination's development stage. This evidence then suggests that SMC bilateral deployment can be beneficial for firms in developed countries, being able to adopt ICT technologies, and detrimental for firms in developing economies, arguably due to their lower capacity to absorb Internet-related technologies. We explore the robustness of this result below.

**Endogeneity issues.** The inclusion of fixed effects at different levels drastically reduces the extent of omitted variable bias. Indeed, most standard gravity-related variables are accounted for through country-year and destination-year fixed effects (e.g. GDP and multilateral resistance for exporting and importing countries, respectively), as well as the country-destination fixed effects (that, for instance, capture distance, common border, common language, colonial ties). However, in Table 3 column 1, we also account for country-destination specific linear trends to further reduce the risk of confounding effects (Bergstrand et al., 2015) and our main results are confirmed.

Previous studies highlighted that the arrival of SMCs is unlikely to be endogenous from the firm's perspective (Hjort and Poulsen, 2019), but the laying of SMCs could be affected by macro conditions, such as the country's outward orientation, which would be a source of reverse

causality bias. Although this concern is mitigated through considering a large set of fixed effects (including country-year fixed effects) and using the lagged explanatory variables, we check this possibility, by implementing the strict exogeneity test as suggested by Wooldridge (2010). This test consists in estimating an equation where, in addition to the lagged values of our main explanatory variables, we also include their contemporaneous and lead values. The coefficients for the lead variables are expected to be not (jointly) statistically significant to exclude reverse causality. In line with these expectations, column 2 of Table 3 shows that when including lagged, current and lead values in our specification, only the coefficients related to the lagged values are statistically significant, confirming that the causality runs from the SMC arrival to the firm participation in the export market, rather than the opposite. It is worth noting that when testing whether the coefficients of the lead variables are not jointly statistically different from zero, the statistics corroborate this hypothesis ( $\chi^2(2) = 1.42$ ,  $p$ -value = 0.488).

**Alternative explanations: the role of bilateral economic integration agreements.** Despite the inclusion of a large set of fixed effects, our results may still be affected by omitted time-varying country-destination characteristics. For instance, the firm's export decision can be affected by the presence of bilateral economic integration agreements (EIAs). Bustos (2011)'s model shows that bilateral trade liberalization leads to a larger fraction of firms to enter the export market, as well as to upgrade their technology. She corroborates these predictions using data from Argentinian firms in the context of a regional trade liberalization episode (i.e. MERCOSUR establishment). The positive effect of EIAs on trade flows is also documented using bilateral trade data and the gravity approach (Bergstrand et al., 2015). In Table 4, we expand our baseline specification by including a dummy variable that takes the value one if the country  $c$  is involved in a bilateral trade agreement with its trade partner  $d$  at time  $t$  ( $EIA_{cdt}$ ), and the related interaction term with  $DC_c$ , to detect differences between high- and low- income countries. Since we lose some observations when considering EIA data,<sup>40</sup> column 1 first replicates the baseline specification with heterogeneity effects across Preferential Trade Agreements (PTAs) explored in columns 2 and 3.

First, the presence of various bilateral IEAs does not affect our results. Second, we provide evidence that EIAs generate positive effects on the number of exporting firms, although they are statistically significant for developing countries only. Third, the EIA effects are heterogeneous across the EIA types.

In column 4, we also control for GATT-WTO and European Union (EU) membership status. Results indicate that EU membership was already captured by the common market status in column 3 whereas multilateral trade liberalization benefits in terms of the number of exporting firms are especially significant for developing countries (an important and comforting result for advocates of multilateralism). In sum, baseline findings are robust to the inclusion of these further controls. We keep finding that the SMC arrival is beneficial for developed countries and detrimental for the developing countries, in terms of firm participation in export markets.

### 5.2. Further investigations

#### 5.2.1. Exploring other export outcomes

**SMC effects on intensive margin of exports, total export value, and export concentration.** Table 5 reports results on other export outcomes in a slightly different sample.<sup>41</sup> After confirming our findings on the

<sup>38</sup> The percentages are computed considering  $[(\exp(\hat{\beta}) - 1) \times 100]\%$ .

<sup>39</sup> When simply accounting for the internet variable at the country-year and destination-year level in line with the existing literature - i.e. an equation like  $N_{exporters_{cdt}} = \exp(\beta_1 SMC_{ct-1} + \beta_2 SMC_{dt-1} + \beta_3 SMC_{ct-1} \times DC_c + \beta_4 SMC_{dt-1} \times DC_c + \alpha_{cd}) + v_{cdt}$ , where  $SMC_{ct-1}$  ( $SMC_{dt-1}$ ) takes a value one if the country  $c$  (destination  $d$ ) has at least one SMC in year  $t - 1$ , and zero otherwise - we find results in line with previous studies (Table B.3), i.e. a high-speed internet connection of a country or its trading partner may exert a positive effect on the number of exporting firms, especially in developing countries. However, this type of analysis is unable to analyze the effect of bilateral digital connectiveness and is more likely to be affected by the omitted variable bias.

<sup>40</sup> Some countries are missing in EIA data.

<sup>41</sup> Data on the number of exporting firms may have missing values when there are zero trade flows, whereas data on average exports per firm (and other export outcomes) in the EDD database have missing values also when there is only one exporting firm at the bilateral level because of confidential issues.

**Table 4**  
Considering the role of bilateral economic integration agreements.

Dep. Var: $N_{exporters_{cdt}}$	(1)	(2)	(3)	(4)
$SMC_{cdt-1}$	0.0879*** (0.0298)	0.0871*** (0.0299)	0.0619** (0.0304)	0.0585* (0.0305)
$SMC_{cdt-1} \times DC_c$	-0.148*** (0.0384)	-0.144*** (0.0381)	-0.122*** (0.0391)	-0.113*** (0.0391)
$EIA_{cdt-1}$		0.000472 (0.0405)		
$EIA_{cdt-1} \times DC_c$		0.0789* (0.0440)		
$PTA_{cdt-1}$			0.0281 (0.0550)	0.0242 (0.0545)
$FTA_{cdt-1}$			-0.0341 (0.0343)	-0.0355 (0.0335)
$CU_{cdt-1}$			1.198*** (0.113)	1.143*** (0.124)
$CM_{cdt-1}$			-0.260** (0.108)	-0.0277 (0.0965)
$EU_{cdt-1}$			-0.152 (0.111)	0.0817 (0.103)
$PTA_{cdt-1} \times DC_c$			0.0215 (0.0628)	0.0213 (0.0621)
$FTA_{cdt-1} \times DC_c$			0.115*** (0.0388)	0.117*** (0.0380)
$CU_{cdt-1} \times DC_c$			-1.214*** (0.125)	-1.182*** (0.127)
$EU_{cdt-1} \times DC_c$			0.527* (0.292)	0.290 (0.296)
$GATT\_WTO_{cdt-1} \times DC_c$				0.188 (0.150)
$GATT\_WTO_{cdt-1} \times DC_c$				0.117*** (0.0376)
$EUROPEAN\_UNION_{cdt-1} \times DC_c$				-0.308*** (0.0981)
Country-Destination FE	YES	YES	YES	YES
Country-Year FE	YES	YES	YES	YES
Destination-Year FE	YES	YES	YES	YES
Observations	59,209	59,209	59,209	58,804
Pseudo $R^2$	0.993	0.993	0.993	0.993

Notes: Unbalanced panel of country-destination pairs. PPML model, where standard errors are corrected for multi-way clustering. Variables:  $N_{exporters_{cdt}}$  is the number of firms in country  $c$  exporting to destination  $d$  in year  $t$ ;  $SMC_{cdt-1}$  is a dummy variable taking value one if country  $c$  is directly connected through at least one SMC to a given destination  $d$  in year  $t-1$  and zero otherwise;  $DC_c$  is a dummy variable taking value one if country  $c$  is a developing economy and zero otherwise.  $EIA_{cdt-1}$  is a dummy variable that takes a value one if the country  $c$  is involved in a bilateral trade agreement with its trade partner  $d$  at time  $t-1$ ;  $PTA_{cdt-1}$ ,  $FTA_{cdt-1}$ ,  $CU_{cdt-1}$ ,  $CM_{cdt-1}$ , and  $EU_{cdt-1}$  are dummy variables that take value one (and zero otherwise) if country  $c$  and its trade partner  $d$  at time  $t-1$  are involved in preferential trade agreements, free trade agreement, custom union, common market, and economic union, respectively;  $GATT-WTO_{cdt-1}$  ( $EUROPEAN-UNION_{cdt-1}$ ) is a dummy variable that takes a value one if both trading partners are GATT-WTO (European Union) members and zero else. \*, \*\*, \*\*\* respectively denote the 10%, 5%, 1% significance levels.

extensive margin (number of exporting firms) in column 1, column 2 shows that the impact of SMC on the intensive margin of exports (average exports per firm) is positive and statistically significant in developing countries, and negative but not statistically significant in developed countries. These results might reflect entry/exit of firms to/from foreign markets. Firms starting to export are likely to be smaller than export incumbents in developed countries, so the export value per firm tends to shrink. Likewise, export exiters are likely to be smaller than export incumbents in developing countries, and therefore, the export value per firm tends to increase. When considering the export value in column 3, we find that the SMC arrival exerts a positive – although not statistically significant – effect in high-income countries,

Consequently, we focus now only on the sub-sample of country-destination pairs that have a positive average export value per firm. For this reason, we replicate the regression on extensive margin along with the intensive margin and other export outcomes.

and a negative significant effect in low-income countries.<sup>42</sup> Therefore, the SMC effects on export value appear to be driven by the extensive margin.<sup>43</sup> Column 4 dispels doubts that SMC arrival might lead to changes in export concentration (measured through the Herfindahl index).

**Detecting export reallocation effects from SMC.** Table 6 examines the SMC arrival on the export value per firm in the first, second, and third quartile of the distribution. The results in columns 1, 2, 3 show that in developed countries, large and medium-size exporters, on average, decrease their export sales following the SMC arrival, while small exporters are not significantly affected. Conversely, in developing countries, we observe an increase in export sales due to the SMC arrival for large and medium-size exporters, with again no statistically significant impact on small exporting firms. These results corroborate the theoretical model’s hint that export reallocation due to SMC goes from large to small firms in high-income countries, and from small to large firms in low-income countries.<sup>44</sup> The ambiguous effects on small exporters might be due to the entry/exit of firms to/from the foreign market. For instance, in developed countries, the average export value per firm in the first quartile (which is closer to the export cutoff in Fig. 3) may increase since incumbent exporters upgrade their digital technology and therefore are able to sell more abroad or may decline because smaller firms enter the export market. Likewise, in developing countries, the export value per firm in the first quartile (which is nearby the export cutoff in 4) may increase because of the exit of the smallest exporters or decrease due to export incumbents’ market share losses to advantage of larger exporters that are able to upgrade the digital technology. For this reason, we focus on incumbent exporters in columns 4, 5, and 6, where results are in line with expectations: export incumbents of any size, on average, have a reduction in the export sales in high-income countries; whereas in low-income countries, large and medium-size export incumbents experience, on average, an increase in export sales at the expense of small firms that shrink their foreign sales.

5.2.2. Exploring heterogeneity

**The role of geographical distance.** Improving Internet access across countries should reduce information frictions, especially between more

<sup>42</sup> In the World Bank’s EDD database, recent years and large countries like USA and China are missing. This could lead us to overlook the influence of technological leaders and recent advances in digital technologies. To mitigate this concern, we replicate our baseline analysis using CEPII Gravity data on export value at the bilateral level coming from BACI database (Conte et al., 2022; Gaulier and Zignago, 2010). This dataset is more comprehensive in terms of country and year coverage. It is also corrected for eventual misreporting in trade flow especially for developing economies (Rozanski and Yeats, 1994). After merging with SMC data, we end up with a balanced panel of 161 countries during the period 1996–2018. Table B.5 shows that SMC effects on export value are consistent with those in Table 5, column 3. When focusing on total exports (column 1) the effect of SMC appears to be positive for developed countries and negative for developing countries, although not statistically significant. When considering only manufacturing goods (column 2), the negative effect of SMC on developing countries’ exports turns out to be statistically significant at 5%.

<sup>43</sup> It could be argued that tougher international competition arising from SMC arrival may lead to a larger number of M&A especially in developing countries, which could explain the reduced number of exporting firms. However, this possibility should be associated with no change or even an increase in total export value. Conversely, we find that SMC arrival leads to a reduction in total export value, which is more likely to be associated with the exit of firms from the foreign market.

<sup>44</sup> They also echo Dickstein and Morales (2018)’s results that large firms have a productivity advantage over small firms and an informational advantage in foreign markets. In developed economies, smaller firms may therefore compensate this disadvantage thanks to Internet adoption, which is less likely the case in developing countries because of their limited digital absorption capacity.

**Table 5**  
The SMC impact on intensive margin, export value, and export concentration.

Dep. Var:	(1)	(2)	(3)	(4)
	Extensive margin $N_{exporters_{cdt}}$	Intensive margin $ave_{exp_{cdt}}$	Export value $exp_{cdt}$	Export concentration $Herf_{index_{cdt}}$
$SMC_{cdt-1}$	0.0806*** (0.0284)	-0.0810 (0.0763)	0.0125 (0.0424)	0.104 (0.0953)
$SMC_{cdt-1} \times DC_c$	-0.139*** (0.0376)	0.262** (0.113)	-0.212*** (0.0760)	-0.0716 (0.110)
Country-Destination FE	YES	YES	YES	YES
Country-Year FE	YES	YES	YES	YES
Destination-Year FE	YES	YES	YES	YES
Observations	48,338	48,338	48,338	48,338
Pseudo $R^2$	0.993	0.892	0.997	0.166

Notes: Unbalanced panel of country-destination pairs. PPML model, where standard errors are corrected for multi-way clustering. Variables:  $N_{exporters_{cdt}}$  is the number of firms in country  $c$  exporting to destination  $d$  in year  $t$ ;  $ave_{exp_{cdt}}$ ,  $exp_{cdt}$  and  $Herf_{index_{cdt}}$  are respectively the average export value per firm, total export value and Herfindahl index of exports in country  $c$  selling to destination  $d$  in year  $t$ ;  $SMC_{cdt-1}$  is a dummy variable taking value one if country  $c$  is directly connected through at least one SMC to a given destination  $d$  in year  $t-1$  and zero otherwise;  $DC_c$  is a dummy variable taking value one if country  $c$  is a developing economy and zero otherwise. \*, \*\*, \*\*\* respectively denote the 10%, 5%, 1% significance levels.

**Table 6**  
The SMC impact on export reallocation across groups of firms with different size.

Dep. Var.: $ave_{exp_{cdt}}$	Export value per exporter			Export value per incumbent		
	(1) 1st Quartile	(2) 2nd Quartile	(3) 3rd Quartile	(4) 1st Quartile	(5) 2nd Quartile	(6) 3rd Quartile
$SMC_{cdt-1}$	-0.0889 (0.0993)	-0.257** (0.101)	-0.247** (0.101)	-0.308** (0.148)	-0.280** (0.118)	-0.217* (0.114)
$SMC_{cdt-1} \times DC_c$	0.0913 (0.147)	0.324** (0.154)	0.369*** (0.140)	0.324 (0.243)	0.421*** (0.161)	0.437*** (0.157)
Country-Destination FE	YES	YES	YES	YES	YES	YES
Country-Year FE	YES	YES	YES	YES	YES	YES
Destination-Year FE	YES	YES	YES	YES	YES	YES
Observations	46,160	46,186	46,160	38,235	38,265	38,235
Pseudo $R^2$	0.866	0.901	0.880	0.939	0.908	0.871

Notes: Unbalanced panel of country-destination pairs. PPML model, where standard errors are corrected for multi-way clustering. Variables:  $SMC_{cdt-1}$  is a dummy variable taking value one if country  $c$  is directly connected through at least one SMC to a given destination  $d$  in year  $t-1$  and zero otherwise;  $DC_c$  is a dummy variable taking value one if country  $c$  is a developing economy and zero otherwise. \*, \*\*, \*\*\* respectively denote the 10%, 5%, 1% significance levels.

geographically distant countries (Lendle et al., 2016). Then, the SMC effect on the number of exporting firms would be expected to be larger when considering more remote destinations. However, recent studies demonstrate that the adoption of the broadband internet makes trade more sensitive to distance (Akerman et al., 2022). If so, then the SMC effect on the number of exporting firms would be expected to be smaller when considering more distant destinations. Table 7 explores these two competing hypotheses through interacting the SMC variable with two alternative bilateral distance metrics: (i) the Euclidian distance in column 1, and (ii) the sea distance in column 2. The results show that our main message holds regardless of the choice of distance metric. We also find that the negative SMC effects for developing countries are smaller when trading partners are more distant geographically.

**The role of digitalization level.** Previous studies have already shown the relevance of high-speed internet through SMCs when analyzing the impact of internet use on firm performance (Hjort and Poulsen, 2019). Here, we exploit the time-varying bilateral level SMC data to investigate how the high-speed internet affects firms' export behavior. It could be that some countries already had access to the Internet prior the SMC arrival via other digital infrastructures, namely satellite and/or overland cables, which would contribute to the total bandwidth available in the country. The presence of these two alternative infrastructures is captured by the set of fixed effects. The presence of satellite is captured by country-year fixed effects, while the presence of overland

**Table 7**  
The role of geographical distance.

Dep. Var: $N_{exporters_{cdt}}$	(1)	(2)
$SMC_{cdt-1}$	0.269** (0.118)	0.202** (0.0935)
$SMC_{cdt-1} \times DC_c$	-0.893*** (0.245)	-0.494*** (0.183)
$SMC_{cdt-1} \times Distance_{cd}$	-0.0244 (0.0162)	-0.0147 (0.0121)
$SMC_{cdt-1} \times DC_c \times Distance_{cd}$	0.0952*** (0.0303)	0.0432* (0.0222)
Country-Destination FE	YES	YES
Country-Year FE	YES	YES
Destination-Year FE	YES	YES
Observations	62,964	64,721
Pseudo $R^2$	0.993	0.993

Notes: Unbalanced panel of country-destination pairs. PPML model, where standard errors are corrected for multi-way clustering. Variables:  $N_{exporters_{cdt}}$  is the number of firms in country  $c$  exporting to destination  $d$  in year  $t$ ;  $SMC_{cdt-1}$  is a dummy variable taking value one if country  $c$  is directly connected through at least one SMC to a given destination  $d$  in year  $t-1$  and zero otherwise;  $DC_c$  is a dummy variable taking value one if country  $c$  is a developing economy and zero otherwise.  $Distance_{cd}$  is population-weighted great circle distance between large cities of the two countries from CEPII database, as in Head et al. (2010) (column 1) or Sea distance from Bertoli et al. (2016) (column 2). \*, \*\*, \*\*\* respectively denote the 10%, 5%, 1% significance levels.

**Table 8**  
The role of digitalization level.

Dep. Var: $N_{exporters_{cdt}}$	(1)	(2)	(3)
$N_{SMC_{cdt-1}}$	0.0251** (0.0110)		
$N_{SMC_{cdt-1}} \times DC_c$	-0.0744*** (0.0178)		
$SMC_{cdt-1}$		0.134 (0.113)	0.120*** (0.0405)
$SMC_{cdt-1} \times DC_c$		0.0617 (0.123)	-0.0876* (0.0494)
$SMC_{cdt-1} \times IBC_{ct-1}$		-0.00188 (0.00814)	
$SMC_{cdt-1} \times DC_c \times IBC_{ct-1}$		-0.0238*** (0.00882)	
$SMC_{cdt-1} \times IUS_{ct-1}$			-0.0580 (0.0681)
$SMC_{cdt-1} \times DC_c \times IUS_{ct-1}$			-0.404*** (0.107)
Country-Destination FE	YES	YES	YES
Country-Year FE	YES	YES	YES
Destination-Year FE	YES	YES	YES
Observations	65,272	57,727	65,146
Pseudo R <sup>2</sup>	0.993	0.994	0.993

Notes: Unbalanced panel of country-destination pairs. PPML model, where standard errors are corrected for multi-way clustering. Variables:  $N_{exporters_{cdt}}$  is the number of firms in country  $c$  exporting to destination  $d$  in year  $t$ ;  $SMC_{cdt-1}$  is a dummy variable taking value one if country  $c$  is directly connected through at least one SMC to a given destination  $d$  in year  $t-1$  and zero otherwise;  $DC_c$  is a dummy variable taking value one if country  $c$  is a developing economy and zero otherwise;  $N_{SMC_{cdt-1}}$  is the number of SMCs connecting any two countries in year  $t-1$ ;  $IBC_{ct-1}$  and  $SIU_{ct-1}$  are respectively the internet bandwidth capacity and share of internet users in country  $c$  at time  $t-1$ .

cables is captured by country-destination fixed effects (Herman and Oliver, 2023).

Yet, bilateral digital connectivity might be heterogeneous in terms of internet bandwidth capacity. Since time-varying data on the Internet bandwidth capacity are not available at the bilateral level, we first proxy the quality of digital connectivity with the number of SMCs connecting directly any two countries, which is expected to increase bilateral internet bandwidth. We use the number of SMCs connecting any two countries in the year  $t-1$ , ( $N_{SMC_{cdt-1}}$ ) as a dependent variable, replacing the dummy variable that captures the presence of at least one SMC at the bilateral level. Table 8, column 1 results show that after the arrival of an additional SMC at the bilateral level, the number of exporting firms increases by about 2.5% in developed economies and falls by about 4.8% in developing economies. Next, we attempt to alternatively address other sources of digital connectivity heterogeneity by interacting our main variable of interest (SMC dummy) with the country-level Internet Bandwidth Capacity variable ( $IBC_{ct-1}$ ) in column 2, or the Share of Internet Users ( $SIU_{ct-1}$ ) in column 3. The results show that the negative impact of an SMC connection on the number of exporting firms in developing countries is amplified as the country's internet bandwidth capacity grows. Similar results are obtained when replacing the IBC variable with the share of internet users, used as a proxy for internet access and usage by the population. The negative SMC impact on the number of exporting firms in developing countries becomes larger as the share of internet users increases.

**The role of population skills.** The SMC impact on the number of exporting firms may switch from negative to positive in the long-run if people can acquire the necessary digital skills. To test this possibility, we first follow the literature on RTA effects (Anderson and Yotov, 2016) by including additional lagged SMC variables from time  $t-2$  to  $t-5$ . The results, reported in Table B.4, show that while the positive effect in developed countries is evident only in the short run, the negative effect in developing countries persists up to five years after the interconnection by SMC. These results suggest that most developing

**Table 9**  
The role of population skills.

Dep. Var: $N_{exporters_{cdt}}$	(1)	(2)
$SMC_{cdt-1}$	0.0680** (0.0318)	0.110 (0.0876)
$SMC_{cdt-1} \times DC_c$	-0.115** (0.0483)	-0.194** (0.0945)
$SMC_{cdt-1} \times Skill_c$		-1.820 (3.019)
$SMC_{cdt-1} \times DC_c \times Skill_c$		9.809** (4.034)
Country-Destination FE	YES	YES
Country-Year FE	YES	YES
Destination-Year FE	YES	YES
Observations	45,062	45,062
Pseudo R <sup>2</sup>	0.994	0.994

Notes: Unbalanced panel of country-destination pairs. PPML model, where standard errors are corrected for multi-way clustering. Variables:  $N_{exporters_{cdt}}$  is the number of firms in country  $c$  exporting to destination  $d$  in year  $t$ ;  $SMC_{cdt-1}$  is a dummy variable taking value one if country  $c$  is directly connected through at least one SMC to a given destination  $d$  in year  $t-1$  and zero otherwise;  $DC_c$  is a dummy variable taking value one if country  $c$  is a developing economy and zero otherwise;  $Skill_c$  is the average yearly change in the share of people with a bachelor's degree for each country.

economies may have been unable to upgrade the digital skills across firms in the subsequent years after the SMC arrival in the time span considered here.

We further explore the role of country-level absorptive capacity by collecting data on the share of people with a bachelor's degree in the World Bank database. To address the issue of missing values in this variable, we compute the average yearly change in the share of people with a bachelor's degree for each country ( $Skill_c$ ), and interact it with the SMC dummy. Results are reported in Table 9. After confirming our baseline findings in column 1 despite sample attrition arising from missing data on skills, column 2 shows that the negative effect of SMCs in developing countries shrinks in countries associated with improvements in the high-skill share of population.

**Sector heterogeneity.** The World Bank's EDD database also provides export data at the country-destination-(HS 2-digit) sector level. This allows to extend the aggregate model in Eq. (8) to account for a sector ( $s$ ) dimension as follows:

$$N_{exporters_{scdt}} = \exp(\beta_1 SMC_{cdt-1} + \beta_2 SMC_{cdt-1} \times DC_c + \alpha_{scd} + \alpha_{sct} + \alpha_{sdt}) + v_{scdt} \tag{9}$$

While the main explanatory variables are kept at the same level as above,  $N_{exporters_{scdt}}$  now refers to the number of firms in sector  $s$  in country  $c$  exporting to destination  $d$  in year  $t$ . Moreover, we consider sector-country-destination fixed effects ( $\alpha_{scd}$ ) to account for time-invariant characteristics at the sector-bilateral level, as well as sector-country-year and sector-destination-year fixed effects ( $\alpha_{sct}$ ,  $\alpha_{sdt}$ ) to control for time-varying characteristics at either sector-country or sector-destination level, such as sector-specific policies in each country or each destination. Standard errors are corrected for multi-way clustering.

Table 10 displays the results. Column 1 shows that the main findings carry on when considering the sector level, though estimates are smaller and slightly less significant statistically. We further explore SMC effects across sectors associated with a different digital intensity. Following Calvino et al. (2018)'s industry classification,<sup>45</sup> we interact our main explanatory variables with a dummy variable taking a value

<sup>45</sup> Calvino et al. (2018) use information on digital indicators from 36 sectors in 12 countries during the period 2001–2015 in order to group different sectors into “high”, “medium-high”, “medium-low” and “low” digital intensity.

**Table 10**  
Considering sector heterogeneity.

Dep. Var: $N_{exporters_{sctd}}$	(1)	(2)
$SMC_{cdt-1}$	0.0664* (0.0350)	0.0620* (0.0342)
$SMC_{cdt-1} \times DC_c$	-0.0916* (0.0530)	-0.0818 (0.0517)
$SMC_{cdt-1} \times HDI_s$		0.129** (0.0654)
$SMC_{cdt-1} \times DC_c \times HDI_s$		-0.321*** (0.108)
Sector-Country-Destination FE	YES	YES
Sector-Country-Year FE	YES	YES
Sector-Destination-Year FE	YES	YES
Observations	1,991,177	1,991,177
Pseudo $R^2$	0.945	0.945

Notes: Unbalanced panel of country-destination pairs. PPML model, where standard errors are corrected for multi-way clustering. Variables:  $N_{exporters_{sctd}}$  is the number of firms in sector  $s$  in country  $c$  exporting to destination  $d$  in year  $t$ ;  $SMC_{cdt-1}$  is a dummy variable taking value one if country  $c$  is directly connected through at least one SMC to a given destination  $d$  in year  $t-1$  and zero otherwise;  $DC_c$  is a dummy variable taking value one if country  $c$  is a developing economy and zero otherwise;  $HDI_s$  is a dummy variable that takes value one if the sector  $s$  is associated with high digital intensity and zero otherwise. \*, \*\*, \*\*\* respectively denote the 10%, 5%, 1% significance levels.

one if the sector  $s$  is associated with high digital intensity ( $HDI_s$ ), and zero otherwise. The results in column 2 show that SMC effects on the number of exporting firms found above are larger and more significant statistically in more digitally intensive sectors.

## 6. Conclusion

By providing direct digital interconnections between trade partners, the laying of SMCs has reduced dramatically communication and information search costs. This paper has explored an undocumented feature of international trade patterns: whether and to what extent the densification of digital networks at the bilateral level has contributed to increase the firm propensity to trade among countries that become connected bilaterally.

We present a heterogeneous firm model *à la* (Melitz, 2003) where the arrival of broadband Internet, although it turns out to be welfare-improving, may have asymmetric effects on firm’s export decision depending on the country’s level of development, thus implying an increase in the welfare gap between high and low-income countries. In the model, most firms in high-income countries can master more advanced digital technology and are therefore more likely to be involved in export activities. By contrast, many firms located in developing economies, which may not have the human, organizational and financial capacities to absorb and master the digital technology, may reduce their export participation, even leaving foreign markets.

By combining data on the bilateral number of exporting firms in 48 countries with an original panel dataset on bilateral SMC deployment, we show that improved bilateral digital connectivity through SMC connections has a positive effect on the number of exporting firms from developed countries, and a negative effect on the number of exporters from developing countries, as predicted in the model. This negative effect of bilateral digital connectivity on firm export participation is stronger in countries from the lower-middle and low-income groups – that is, in the Middle East & North Africa and Sub-Saharan Africa.

Thus, the availability of better digital technology for firms in developing countries is a necessary but not sufficient condition to enable them to better compete internationally. Importantly, we show that among developing countries getting connected by SMCs, those that experience an increase in skills have a smaller decline in the number of exporting firms than those with unchanged skills. While this is documented for producers of goods in our study, we may expect similar results for services providers, given that high-income countries have a comparative advantage in services. However, it should be noted that the SMC effects are more likely to vary across service industries — particularly in ICT-related service activities such as call centers — where several lower-income regions have invested in infrastructure and skills. In these cases, bilateral SMC connections can facilitate the participation of services firms in export markets even in the context of a developing economy, with potentially different implications for exporting firm dynamics and welfare.

Overall, our findings indicate that the availability of submarine cable infrastructure must be complemented by improvements in the broader digital environment, such as investments in digital skills (as documented in our analysis) and/or last-mile infrastructure, to enable firms to compete effectively on the international stage. A pivotal aspect of this improvement is accessibility to fixed broadband internet, both in terms of affordability and infrastructure coverage. In many low-income countries, internet access predominantly relies on mobile broadband,<sup>46</sup> which, while widespread, often lacks the reliability and capacity necessary for firms to fully leverage internet-based sophisticated technologies in their production and export processes. This reliance on mobile broadband likely hinders the adoption of advanced technologies such as artificial intelligence and cloud-based services that are becoming integral to modern economic activities. Additionally, the currently lower mastering of digital technology in these countries makes them more vulnerable to cyberthreats, such as cyberattacks and disinformation campaigns. This vulnerability to increasing digital risks reduces the profitability of firms’ investments in ICT likely hindering their ability to establish a foothold in, and consistently supply, foreign markets. While the results identify low digital skills as impediments, other forces are likely to be at play. For example, digital trade regulations related to connectivity and information flows across countries may influence the role of digital connectivity in reducing trade costs. These could be elucidated in a model incorporating mechanisms accounting for productivity differences across firms and disentangled in firm-level panel data covering several countries and sectors (including services industries) with more detailed information on factors affecting firm exports by destination.

## CRedit authorship contribution statement

**Michele Imbruno:** Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Joël Cariolle:** Writing – original draft, Investigation, Data curation. **Jaime de Melo:** Writing – original draft.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

<sup>46</sup> See ITU data at: <https://www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx>.

## Appendix A. Theoretical results and comparative statics

### A.1. The developed economy case

Considering the Eqs. (1), (2), and (3), as well as the free entry condition in Section 3.1, we can determine that

the survival cutoff is  $\varphi_l^d = \left[ \left( \frac{\sigma-1}{k-\sigma+1} \right) \frac{1}{\delta f_e} \right]^{\frac{1}{k}} \Delta^{\frac{1}{k}}$ , where  $\Delta = f + \psi_h f_h + \psi_x f_x$

the digital technology cutoff is  $\varphi_h^d = \left[ \frac{f_h}{f(\gamma^{\sigma-1}-1)} \right]^{\frac{1}{\sigma-1}} \varphi_l^d$

the export cutoff is  $\varphi_x^d = \left( \frac{f_x}{f\gamma^{\sigma-1}} \right)^{\frac{1}{\sigma-1}} \varphi_l^d$

the probability of survival is  $\psi_d = (\varphi_l^d)^{-k}$

the probability of digital technology adoption  $\psi_h = \left( \frac{\varphi_h^d}{\varphi_l^d} \right)^{-k} = \left[ \frac{f_h}{f(\gamma^{\sigma-1}-1)} \right]^{\frac{-k}{\sigma-1}}$

the probability of exporting is  $\psi_x = \left( \frac{\varphi_x^d}{\varphi_l^d} \right)^{-k} = \left( \frac{f_x}{f\gamma^{\sigma-1}} \right)^{\frac{-k}{\sigma-1}}$

the number of surviving firms is  $N = \frac{R}{\bar{r}} = \frac{L}{\sigma(\bar{\pi}+\Delta)} = \left( \frac{k-\sigma+1}{k} \right) \frac{L}{\sigma\Delta}$

the number of exporting firms is  $N_x = \psi_x N = \left( \frac{f_x}{f\gamma^{\sigma-1}} \right)^{\frac{-k}{\sigma-1}} \left( \frac{k-\sigma+1}{k} \right) \frac{L}{\sigma\Delta}$

the price index is  $P = \left( \frac{L}{\sigma f} \right)^{\frac{1}{1-\sigma}} \frac{\sigma}{\sigma-1} \frac{1}{\varphi_l^d}$

Therefore, the derivative of  $N_x$  w.r.t.  $\gamma$  is

$$\frac{\partial N_x}{\partial \gamma} = \frac{\partial \psi_x}{\partial \gamma} N + \frac{\partial N}{\partial \gamma} \psi_x = k\psi_x \gamma^{-1} N \left[ 1 - \Delta^{-1} \left( \frac{\gamma^{\sigma-1}}{\gamma^{\sigma-1}-1} \psi_h f_h + \psi_x f_x \right) \right] > 0$$

### A.2. The developing economy case

Considering the Eqs. (4), (5), and (6), as well as the free entry condition in , we can determine that

the survival cutoff is  $\varphi_l^d = \left[ \left( \frac{\sigma-1}{k-\sigma+1} \right) \frac{1}{\delta f_e} \right]^{\frac{1}{k}} \Delta^{\frac{1}{k}}$ , where  $\Delta = f + \psi_x f_x + \psi_h f_h$

the export cutoff is  $\varphi_x^d = \left( \frac{f_x}{f} \right)^{\frac{1}{\sigma-1}} \varphi_l^d$

the digital technology cutoff is  $\varphi_h^d = \left[ \frac{f_h}{f2(\gamma^{\sigma-1}-1)} \right]^{\frac{1}{\sigma-1}} \varphi_l^d$

the probability of survival is  $\psi_d = (\varphi_l^d)^{-k}$

the probability of exporting is  $\psi_x = \left( \frac{\varphi_x^d}{\varphi_l^d} \right)^{-k} = \left( \frac{f_x}{f} \right)^{\frac{-k}{\sigma-1}}$

the probability of digital technology adoption is  $\psi_h = \left( \frac{\varphi_h^d}{\varphi_l^d} \right)^{-k} = \left[ \frac{f_h}{f2(\gamma^{\sigma-1}-1)} \right]^{\frac{-k}{\sigma-1}}$

the number of surviving firms is  $N = \frac{R}{\bar{r}} = \frac{L}{\sigma(\bar{\pi}+\Delta)} = \left( \frac{k-\sigma+1}{k} \right) \frac{L}{\sigma\Delta}$

the number of exporting firms is  $N_x = \psi_x N = \left( \frac{f_x}{f} \right)^{\frac{-k}{\sigma-1}} \left( \frac{k-\sigma+1}{k} \right) \frac{L}{\sigma\Delta}$

the price index is  $P = \left( \frac{L}{\sigma f} \right)^{\frac{1}{1-\sigma}} \frac{\sigma}{\sigma-1} \frac{1}{\varphi_l^d}$

Therefore, the derivative of  $N_x$  w.r.t.  $\gamma$  is

$$\frac{\partial N_x}{\partial \gamma} = \psi_x \frac{\partial N}{\partial \gamma} = -\psi_x N \Delta^{-1} k\psi_h (\gamma^{\sigma-1} - 1)^{-1} \gamma^{\sigma-1} f_h < 0$$

### A.3. Welfare analysis

In our model, welfare  $W$  corresponds to wage divided by the price index so it can be written in terms of the survival productivity cutoff  $\varphi_l^d$  and parameters. Recalling that the wage has been normalized to one ( $w = 1$ ).

$$W = \left( \frac{L}{\sigma f} \right)^{\frac{1}{\sigma-1}} \frac{\sigma-1}{\sigma} \varphi_l^d$$

To measure welfare effects from digital technology adoption, we compare welfare after using digital technology at time 1 with welfare without any digital technology at time 0 as follows

$$WG = \frac{W^1}{W^0} = \left( \frac{f + \psi_x^1 f_x + \psi_h^1 f_h}{f + \psi_x^0 f_x} \right)^{\frac{1}{k}}$$

where  $\psi_x^0 = \left( \frac{f_x}{f} \right)^{\frac{-k}{\sigma-1}}$  in both cases considered in our framework. Indeed, in absence of digital technology, developed economy case is identical to developing economy case, given that all parameters are identical. Considering Appendices A.1 and A.2,  $WG > 1$  in any case, i.e. we can always highlight gains from digital technology adoption regardless of the development context under analysis. To see whether welfare gains are different

between the two cases, we compare welfare gain of developed economy case ( $DC = 0$ ) with that one of developing economy case ( $DC = 1$ ) as follows

$$\frac{WG_{(DC=0)}}{WG_{(DC=1)}} = \left( \frac{f + \psi_{x(DC=0)}^1 f_x + \psi_{h(DC=0)}^1 f_{h(DC=0)}}{f + \psi_{x(DC=1)}^1 f_x + \psi_{h(DC=1)}^1 f_{h(DC=1)}} \right)^{\frac{1}{k}}$$

First,  $\psi_{x(DC=0)}^1 f_x > \psi_{x(DC=1)}^1 f_x$  always holds in our model because while the fixed cost of exporting is assumed to be identical across the two cases (as the fixed cost of production), the probability of exporting subsequent the digital technology adoption is always higher in the developed economy case ( $\psi_{x(DC=0)}^1 > \psi_{x(DC=1)}^1 = \psi_x^0$ ). When comparing the term  $\psi_h^1 f_h$  across the two cases, the result is not straightforward because the fixed cost of digital technology adoption is relatively higher in the developing economy case ( $f_{h(DC=1)} > f_{h(DC=0)}$ ), but the probability of adopting digital technology is relatively higher in the developed economy case ( $\psi_{h(DC=0)}^1 > \psi_{h(DC=1)}^1$ ). Therefore  $\frac{WG_{(DC=0)}}{WG_{(DC=1)}}$  is certainly higher than one only

if  $\frac{\psi_{h(DC=0)}^1 f_{h(DC=0)}}{\psi_{h(DC=1)}^1 f_{h(DC=1)}} > 1$ . Considering the equations in [Appendices A.1](#) and [A.2](#):

$$\frac{\psi_{h(DC=0)}^1 f_{h(DC=0)}}{\psi_{h(DC=1)}^1 f_{h(DC=1)}} = \frac{f_{h(DC=0)} \left[ \frac{f_{h(DC=0)}}{2} \right]^{\frac{-k}{\sigma-1}}}{f_{h(DC=1)} \left[ \frac{f_{h(DC=1)}}{2} \right]^{\frac{-k}{\sigma-1}}}$$

$$= \left( \frac{1}{2} \right)^{\frac{k}{\sigma-1}} \left[ \frac{f_{h(DC=1)}}{f_{h(DC=0)}} \right]^{\frac{k-\sigma+1}{\sigma-1}}$$

Therefore,  $\frac{\psi_{h(DC=0)}^1 f_{h(DC=0)}}{\psi_{h(DC=1)}^1 f_{h(DC=1)}} > 1$  only if  $\frac{f_{h(DC=1)}}{f_{h(DC=0)}} > 2^{\frac{k}{k-\sigma+1}}$ .

## Appendix B. Additional tables and figures

### B.1. Additional tables

See [Tables B.1–B.5](#).

**Table B.1**

Unbalanced panel of bilateral trade (1997–2014): Sample distribution across 48 countries and 7 regions.

Country (ISO)	Country (full name)	EAP	ECA	LAC	MENA	SA	SSA	OTHERS
ALB	Albania	0	1512	0	0	0	0	0
BEL	Belgium	0	0	0	0	0	0	2856
BGD	Bangladesh	0	0	0	0	1680	0	0
BGR	Bulgaria	0	1008	0	0	0	0	0
BRA	Brazil	0	0	3024	0	0	0	0
CHL	Chile	0	0	1680	0	0	0	0
CIV	Cote d'Ivoire	0	0	0	0	0	672	0
CMR	Cameroon	0	0	0	0	0	2856	0
COL	Colombia	0	0	1176	0	0	0	0
CRI	Costa Rica	0	0	2520	0	0	0	0
DEU	Germany	0	0	0	0	0	0	672
DNK	Denmark	0	0	0	0	0	0	2016
DOM	Dominican Republic	0	0	2184	0	0	0	0
ECU	Ecuador	0	0	2184	0	0	0	0
EGY	Egypt, Arab Rep.	0	0	0	1176	0	0	0
ESP	Spain	0	0	0	0	0	0	1680
EST	Estonia	0	0	0	0	0	0	2520
GAB	Gabon	0	0	0	0	0	1176	0
GEO	Georgia	0	1680	0	0	0	0	0
GIN	Guinea	0	0	0	0	0	672	0
GTM	Guatemala	0	0	1512	0	0	0	0
HRV	Croatia	0	1008	0	0	0	0	0
IRN	Iran, Islamic Rep.	0	0	0	840	0	0	0
JOR	Jordan	0	0	0	1680	0	0	0
KEN	Kenya	0	0	0	0	0	1512	0
KHM	Cambodia	1680	0	0	0	0	0	0
KWT	Kuwait	0	0	0	0	0	0	336
LBN	Lebanon	0	0	0	840	0	0	0
LKA	Sri Lanka	0	0	0	0	168	0	0

(continued on next page)

<sup>47</sup> See [Table B.1](#) for the full names of the countries.

Table B.1 (continued).

Country (ISO)	Country (full name)	EAP	ECA	LAC	MENA	SA	SSA	OTHERS
MAR	Morocco	0	0	0	2016	0	0	0
MDG	Madagascar	0	0	0	0	0	1008	0
MEX	Mexico	0	0	2184	0	0	0	0
MMR	Myanmar	504	0	0	0	0	0	0
MUS	Mauritius	0	0	0	0	0	1848	0
NIC	Nicaragua	0	0	2184	0	0	0	0
NOR	Norway	0	0	0	0	0	0	3024
PAK	Pakistan	0	0	0	0	1512	0	0
PER	Peru	0	0	2856	0	0	0	0
PRT	Portugal	0	0	0	0	0	0	2688
SEN	Senegal	0	0	0	0	0	2184	0
STP	Sao Tome and Principe	0	0	0	0	0	168	0
SWE	Sweden	0	0	0	0	0	0	1680
THA	Thailand	504	0	0	0	0	0	0
TUR	Turkey	0	2016	0	0	0	0	0
TZA	Tanzania	0	0	0	0	0	1680	0
URY	Uruguay	0	0	2016	0	0	0	0
YEM	Yemen	0	0	0	840	0	0	0
ZAF	South Africa	0	0	0	0	0	2016	0
<b>TOT</b>		<b>2688</b>	<b>7224</b>	<b>23,520</b>	<b>7392</b>	<b>3360</b>	<b>15,792</b>	<b>17,472</b>

Notes: EAP = East Asia & the Pacific; ECA = Europe & Central Asia; LAC = Latin America & the Caribbean; MENA = Middle East & North Africa; OTHERS = Developed Economies; SA = South Asia; SSA = Sub-Saharan Africa.

Table B.2  
Summary statistics.

Variable	Obs	Mean	Std. Dev.	Min	Max
$N_{exporters_{cdt}}$	77,448	261.038	1179.869	0	32,648
$SMC_{cdt}$	77,448	0.086	0.281	0	1
$DC_c$	77,448	.774	.418	0	1

Table B.3  
The effects of SMC at the country level and destination level.

Dep. Var: $N_{exporters_{cdt}}$	(1)	(2)
$SMC_{ct-1}$	0.0613*** (0.0210)	-0.0174 (0.0312)
$SMC_{dt-1}$	0.153*** (0.0364)	0.0541 (0.0491)
$SMC_{ct-1} \times DC_c$		0.0881** (0.0420)
$SMC_{dt-1} \times DC_c$		0.235*** (0.0735)
Country-Destination FE	YES	YES
Year FE	YES	YES
Observations	65,421	65,421
Pseudo $R^2$	0.988	0.988

Notes: Unbalanced panel of country-destination pairs. PPML model, where standard errors are corrected for clustering at the bilateral level. Variables:  $N_{exporters_{cdt}}$  is the number of firms in country  $c$  exporting to destination  $d$  in year  $t$ ; where  $SMC_{ct-1}$  ( $SMC_{dt-1}$ ) takes a value one if the country  $c$  (destination  $d$ ) has at least one SMC in year  $t-1$ , and zero otherwise;  $DC_c$  is a dummy variable taking value one if country  $c$  is a developing economy and zero otherwise. \*, \*\*, \*\*\* respectively denote the 10%, 5%, 1% significance levels.

**Table B.4**  
Long-term effects of SMCs on the number of exporting firms.

Dep. Var: $N_{exporters_{cdt}}$	(1)	(2)	(3)	(4)
$SMC_{cdt-1}$	0.0713*** (0.0269)	0.0728*** (0.0266)	0.0730*** (0.0267)	0.0715*** (0.0267)
$SMC_{cdt-1} \times DC_c$	-0.0750** (0.0361)	-0.0757** (0.0357)	-0.0761** (0.0359)	-0.0754** (0.0359)
$SMC_{cdt-2}$	0.0203 (0.0327)	-0.00237 (0.0273)	-0.00162 (0.0273)	-0.000236 (0.0271)
$SMC_{cdt-2} \times DC_c$	-0.0915** (0.0418)	-0.00608 (0.0356)	-0.00627 (0.0353)	-0.00563 (0.0353)
$SMC_{cdt-3}$		0.0254 (0.0303)	-0.000173 (0.0249)	0.000422 (0.0248)
$SMC_{cdt-3} \times DC_c$		-0.107*** (0.0384)	-0.0128 (0.0333)	-0.0138 (0.0332)
$SMC_{cdt-4}$			0.0274 (0.0264)	-0.00207 (0.0212)
$SMC_{cdt-4} \times DC_c$			-0.114*** (0.0303)	-0.0292 (0.0252)
$SMC_{cdt-5}$				0.0320 (0.0277)
$SMC_{cdt-5} \times DC_c$				-0.101*** (0.0296)
Country-Destination FE	YES	YES	YES	YES
Country-Year FE	YES	YES	YES	YES
Destination-Year FE	YES	YES	YES	YES
Observations	65,272	65,272	65,272	65,272
Pseudo $R^2$	0.993	0.993	0.993	0.993

Notes: Unbalanced panel of country-destination pairs. PPML model, where standard errors are corrected for multi-way clustering. Variables:  $N_{exporters_{cdt}}$  is the number of firms in country  $c$  exporting to destination  $d$  in year  $t$ ;  $SMC_{cdt-1}$  is a dummy variable taking value one if country  $c$  is directly connected through at least one SMC to a given destination  $d$  in year  $t - 1$  and zero otherwise;  $DC_c$  is a dummy variable taking value one if country  $c$  is a developing economy and zero otherwise. \*, \*\*, \*\*\* respectively denote the 10%, 5%, 1% significance levels.

**Table B.5**  
Bilateral-level linkage between SMC arrival and export value (from CEPII data).

Dep. Var: $exp_{cdt}$	(1)	(2)
	All exports	Manufacturing exports
$SMC_{cdt-1}$	0.0148 (0.0205)	-0.00910 (0.0191)
$SMC_{cdt-1} \times DC_c$	-0.0181 (0.0392)	-0.0696** (0.0337)
Country-Destination FE	YES	YES
Country-Year FE	YES	YES
Destination-Year FE	YES	YES
Observations	470,889	468,903
Pseudo $R^2$	0.9925	0.995

Notes: Unbalanced panel of country-destination pairs. PPML model, where standard errors are corrected for multi-way clustering. Variables:  $exp_{cdt}$  is the export value in country  $c$  exporting to destination  $d$  in year  $t$ ;  $SMC_{cdt-1}$  is a dummy variable taking value one if country  $c$  is directly connected through at least one SMC to a given destination  $d$  in year  $t - 1$  and zero otherwise;  $DC_c$  is a dummy variable taking value one if country  $c$  is a developing economy and zero otherwise. \*, \*\*, \*\*\* respectively denote the 10%, 5%, 1% significance levels.

B.2. Additional figures

See Figs. B.1–B.7.

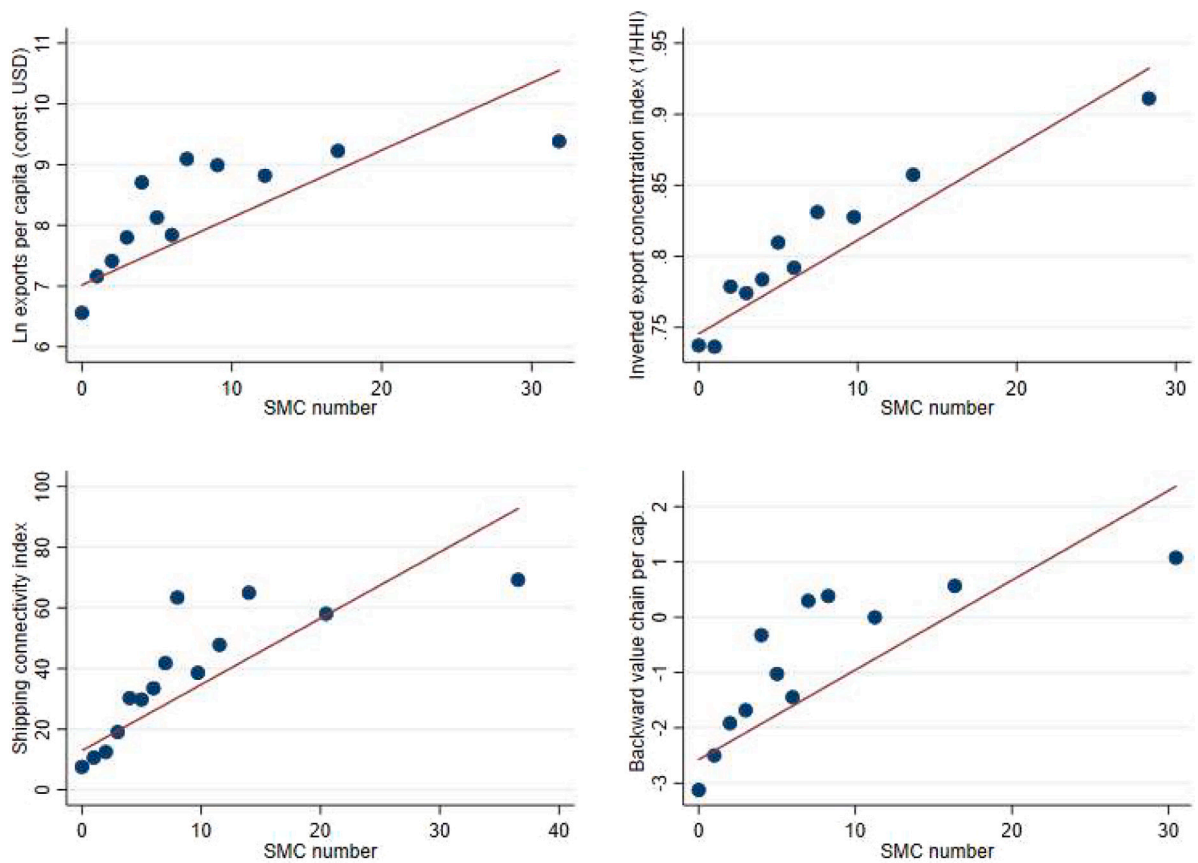


Fig. B.1. Binned scatterplot of SMC number against indicators of insertion in global trade (1995–2018).

Notes: Authors' elaboration. Data from [Telegeography](#), and [World Development Indicators](#).

Notes: Top left-hand side graph is built from 3227 observations. Top right-hand side graph is built from 3987 observations. Bottom left-hand side graph is built from 2036 observations. Bottom right-hand side graph is built from 3624 observations.



Fig. B.2. East Asia and the Pacific<sup>47</sup>.

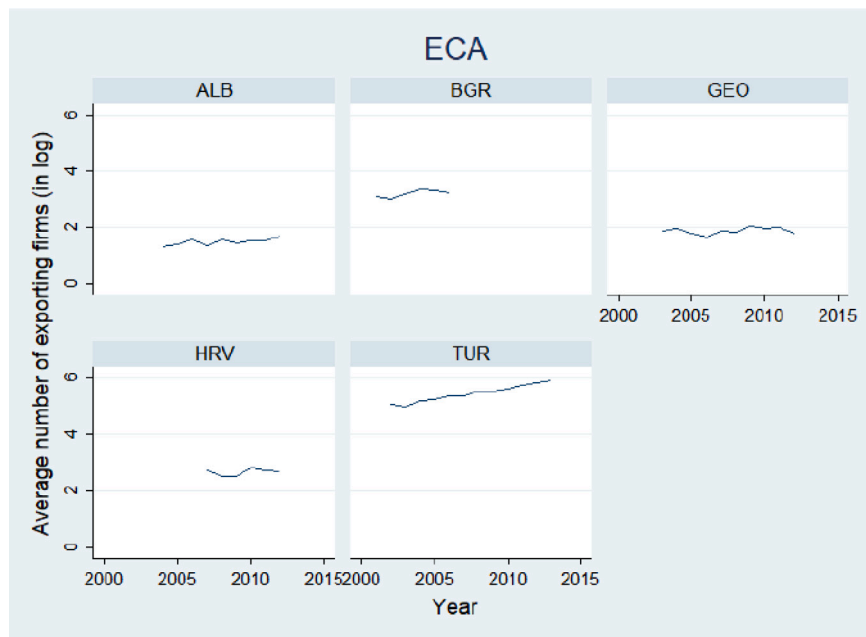


Fig. B.3. Europe and Central Asia.

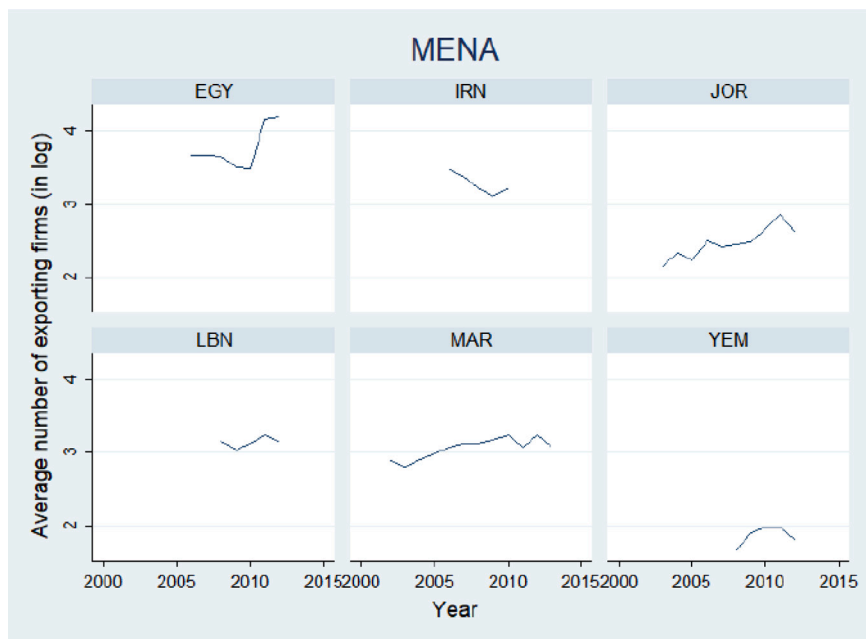


Fig. B.4. Middle East & North Africa.

**Data availability**

Data will be made available on request.



Fig. B.5. South Asia. Notes: Sri Lanka is missing because only one-year data are available.

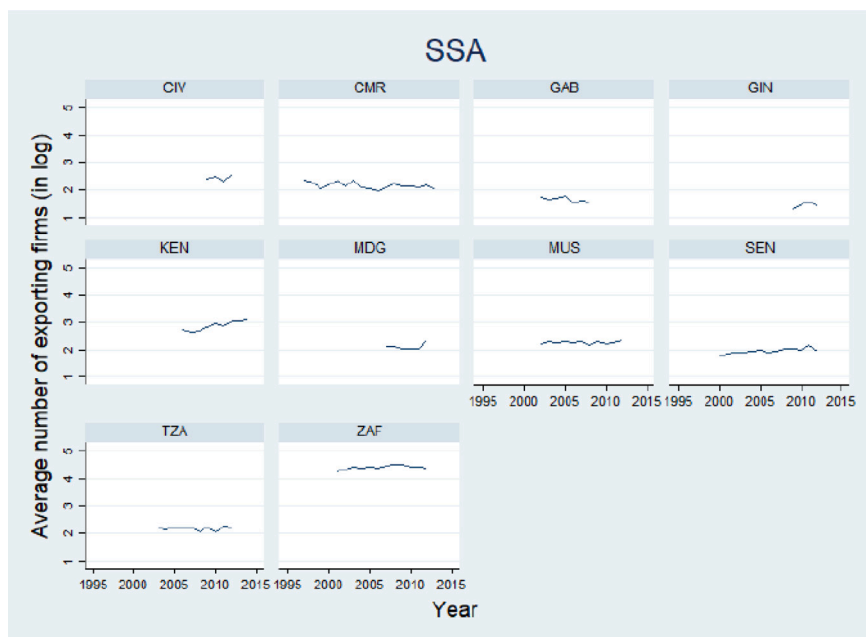


Fig. B.6. Sub-Saharan Africa. Notes: Sao Tomé is missing because only one-year data are available.

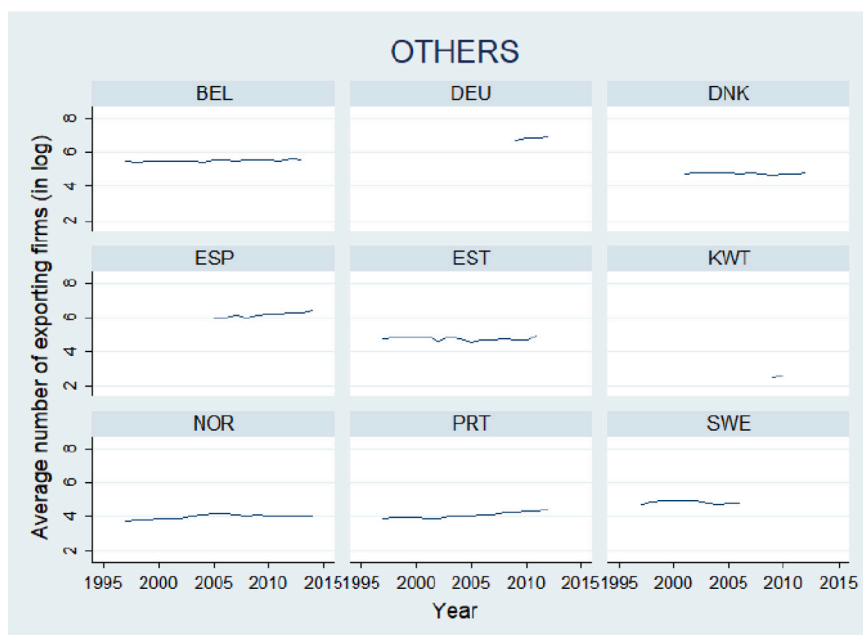


Fig. B.7. Others. Notes: OTHERS includes countries from Western Europe and Kuwait.

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