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Examining the impact of digital technologies on trade in Pacific island countries

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Examining the impact of digital technologies on trade in Pacific island countries

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Abstract

This study examines the role of information and communication technologies (ICT) on trade in six Pacific island countries (PICs). To test this, we apply the augmented gravity model of trade with ICT variables, namely fixed broadband rate, Internet rate, landline and mobile phone rates for the period 2000 to 2017. Empirical results from the gravity model are mixed. We find that fixed broadband rate and Internet rate are positively related to exports of goods in PICs. However, we observe unexpected negative coefficients for landline and mobile phone rates on exports of goods of PICs. Our findings suggest that there is scope to improve the access, quality, and affordability of ICT or digital technologies in PICs. We also infer that the digital divide in connecting the unconnected populations still poses a challenge in PICs. Hence, by leveraging digital technologies, PICs can boost trade with their trading partners and raise economic growth.

Keywords: ICT, trade, PICs

1. Introduction

Trade inclusivity is widely viewed as essential in the PICs since it promotes economic prosperity and well-being for people in the region (Chen et al., 2019; Asian Development Bank, 2022). Trade facilitates the allocation of resources, transfer of technological knowledge and advancements. It also raises economic growth, creates employment, reduces household poverty levels, and improves social welfare and living standards.

Over the period 2000 to 2017, average trade-to-GDP ratios for the six PICs in our study stood at 90.5 percent, indicating the significance of trade in these economies. However, these PICs are vulnerable to trade shocks due to their small market size, openness, geographical remoteness and limited diversification opportunities. In this regard, digital technologies or enhanced ICT capabilities are recognised as a crucial element to help address the common challenges faced by PICs, particularly in improving competitiveness and accelerating international trade (Di Caprio & Daza, 2015).

Digital trade has prompted business competitors to develop and implement new business models and trading strategies, changing the global industrial, supply, value, and innovation chains, and becoming a major player in global trade (Standing Committee of Wuhan Municipal Party, 2021).[1] Digital technologies have also changed the composition of trade, with countries having an advanced level of automation and technology capturing a higher value in the production network. This may further entice better quality investments and create exports with higher technology content (UNCTAD, 2019), including improved rules on intellectual property rights, data flows, and privacy.

Similarly, ICT innovations—such as mobile phones, email, virtual conferences, development of electronic payment and e-commerce platforms—have helped countries to overcome significant geographical barriers and distance from global markets, forge closer trade ties, enter new markets for innovative quality products and expand their consumer base (Freund & Weinhold, 2004a; Kiveu, 2013; Dokic, 2018; WTO, 2018). As per the ICT-led trade cost reduction theory, countries that are far apart would be able to trade more frequently than countries that are closer.[2] Notably, countries using more ICT have stronger gravitational attraction, resulting in increased trade flows (Malone et al., 1987; Eaton & Kortum, 2002; Demirkan et al., 2009).

Improvements in ICT infrastructure, as well as the adoption of innovative digital applications and solutions has also boosted productivity and resulted in lower trade costs and lower cost of doing business (Spanos et al., 2002; Demirkan et al., 2009; Ozcan, 2018). This enables traders to access, process and disseminate accurate and timely market information, which results in better planning and opportunities for new business models (Venables, 2001; Freund & Weinhold, 2004a; Lin, 2015; Hanna, 2016). Additionally, firms could sell their goods and services at competitively lower prices (Makepe, et al., 2012; Nipo et al., 2018) allowing them to outperform their competitors (World Bank, 2016).

Despite the theoretical merits of ICT on international trade, empirical evidence is mixed. Studies have found a positive relationship between ICT and trade (Clarke & Wallsten, 2007; Vemuri and Siddiqi, 2009; Demirkan, et al., 2009; Ahmad, et al., 2011) while the others have shown a negative correlation between ICT and trade (Chung et. al., 2013; Thienmann, Flemming, & Mueller, 2012; Nipo et al., 2018). The mixed results can be explained by the data and research methodology used, ICT infrastructure quality, ICT penetration level,

government rules and regulations, an enabling business climate, a well-functioning financial system, research and development, human capital quality and economic size.

To our knowledge, existing studies on the trade-enhancing effect of digital technologies in PICs are sparse, hence our main objective to study the role of ICT on trade in six PICs aims to fill in this gap. Digital trade has the potential to expand the PICs narrow export base, improve competitiveness and spur international trade. Following the literature, we apply the augmented gravity model on goods exports with ICT variables—mobile phones, fixed telephones, Internet, and fixed broadband—for six PICs, covering the period 2000 to 2017. The main results of this study indicate that the influence of ICT variables on merchandise exports of the six PICs to trading partner countries are mixed. This also suggest that the digital divide in connecting the unconnected populations is a challenge due to the insufficient ICT levels and supporting infrastructure and high costs due to lack of economies of scale in PICs.

The remainder of this paper is organised as follows: Section 2 provides the study context of the six PICs covering their economic performances, digital trends and bilateral trade patterns; Section 3 covers the literature review; Section 4 presents the data description, descriptive statistics, and the method; Section 5 is devoted to the discussion of the empirical results; and Section 6 concludes with some policy suggestions.

2. Study context

2.1 A snapshot on PICs economic performances

Economic growths in the six PICs—Fiji, PNG, Solomon Islands, Vanuatu, Tonga, and Western Samoa—have been volatile for the period 2000 to 2017 (Table A1). The ability of these PICs to lift their growth performance has been hampered by several challenges, including their remote distance from global markets, narrow production and export bases, lack of economies of scale due to small domestic markets and population (excluding PNG), limited diversification opportunities, and high costs (United Nations, 2010). Structural issues related to natural disasters and climate change effects, weak macroeconomic policies and political instability have also stalled economic progress and development.

Looking at the growth performances, Fiji's growth rate averaged 0.3 percent between 2005 and 2009, down from an annual average growth rate of 2.0 percent (2000-2004), largely affected by the global financial crisis and devaluation of the Fiji dollar. Fiji's economy improved thereafter, averaging around 3.5 percent (2010-2014) and 4.1 percent (2015-2017), respectively. Western Samoa grew at an annual average rate of 5.5 percent (2000-2004), but slowed considerably to 1.7 percent (2005-2009) and 0.0 percent (2010-2014) due to the global financial crisis, higher commodity prices and natural disasters (a tsunami in 2009, a cyclone in 2012). PNG achieved higher growths (above 5 percent on average) compared to other PICs from 2005 to 2017, as the country benefitted from the higher energy prices and liquefied natural gas projects. Vanuatu's economy grew by 1.1 percent on average between 2000 and 2004 affected by a weak external environment and slow structural reforms due to government changes. Growth also slowed to 1.8 percent on average between 2010 and 2014 (from 5.1 percent in 2005-2009), due to political instability and limited capacity. However, Vanuatu's economic growth rebounded to 3.8 percent on average (2015-2017), supported by the pickup in tourism activity. The Solomon Islands economy contracted by -2.4 percent on average between 2000 and 2004, due to civil unrest. The economy recovered thereafter, achieving annual average growth rates of above 4.0 percent for the period 2005 to 2017. Domestic political disturbances and violence caused a drag on Tonga's growth from 2005 to 2009 (0.0 percent, from 1.9 percent 2000-2004), but improved from 2010-2014 (2.2 percent) and 2015-2017 (3.7 percent).

Inflation outcomes in the PICs are mainly influenced by sharp fluctuations in global oil and food prices, weather-related disruptions, and fiscal policy changes. Annual inflation rates in the six PICs averaged within the range of 2.6 percent to 10.7 percent between 2000 and 2004, owing to higher food and oil prices and the 2002 earthquake in PNG. Following a series of natural disasters—the 2007 earthquake and accompanying tsunami in Solomon Islands, the 2009 tsunami in Samoa, and the 2009 flash floods in Fiji—inflation rates hovered around the range of 3.3 percent to 10.1 percent between 2005 and 2009. Inflation then moderated to a range of 1.4 percent to 5.0 percent from 2010 to 2014, and to a range of 0.1 percent to 6.0 percent from 2015 to 2017.

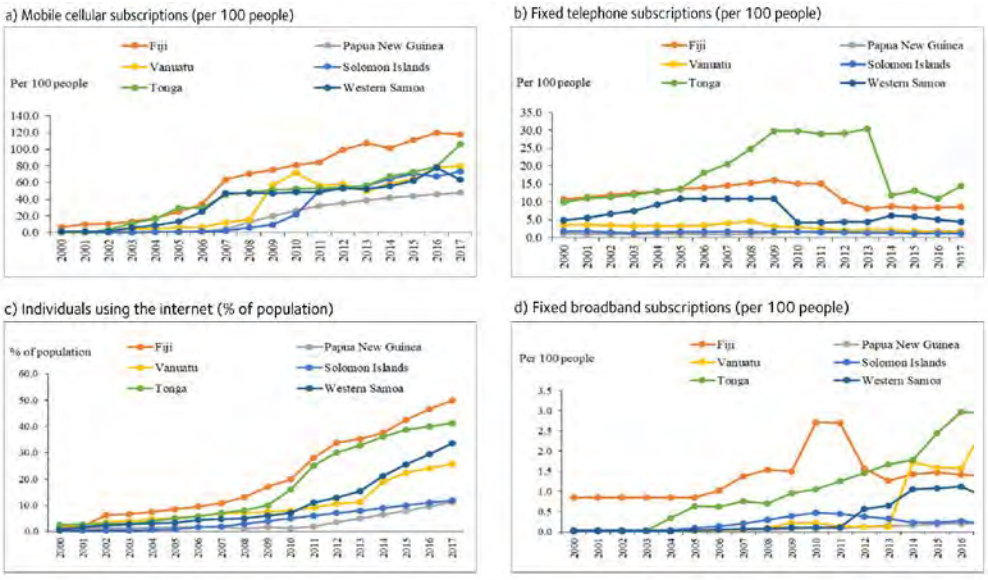
2.2 Digital trends in the PICs

Digital uptake in the six PICs started to gain momentum from the mid to late 2000s. This progress is supported by the liberalisation of domestic telecommunications market— Tonga in 2002, Samoa in 2005, PNG in 2007, Fiji and Vanuatu in 2008, Solomon Islands in 2009[3]—which led to the entry of new service providers and spurred competition (e.g., Vodafone and Digicel), deployment of submarine cables[4], ICT investment and Government incentives, among others.

The subsequent improvements in ICT infrastructure including installation of submarine cables led to an increase in Internet bandwidth and low-cost connectivity, as previously PICs had to rely on expensive satellite connectivity which limited their access to the Internet. However, expansions in satellites are still important in PICs as the dispersed geographic location require costly and long cable lengths.

Digital connectivity via mobile subscriptions in PICs followed an upward trend, indicating that more people are accessing the Internet via mobile as it offers greater mobility and flexibility (Figure 1a). Fiji as the most developed economy in the Pacific region has the highest mobile penetration, averaging 63.9 per 100 people between 2000 and 2017, followed by Tonga (43.2 per 100 people), Western Samoa (36.7 per 100 people), Vanuatu (34.9 per 100 people), and Solomon Islands (26.7 per 100 people). Although PNG has the largest population relative to the rest of the PICs, it has a low mobile penetration of 19.6 per 100 people on average.

Figure 1: The four key ICT variables of the six selected PICs



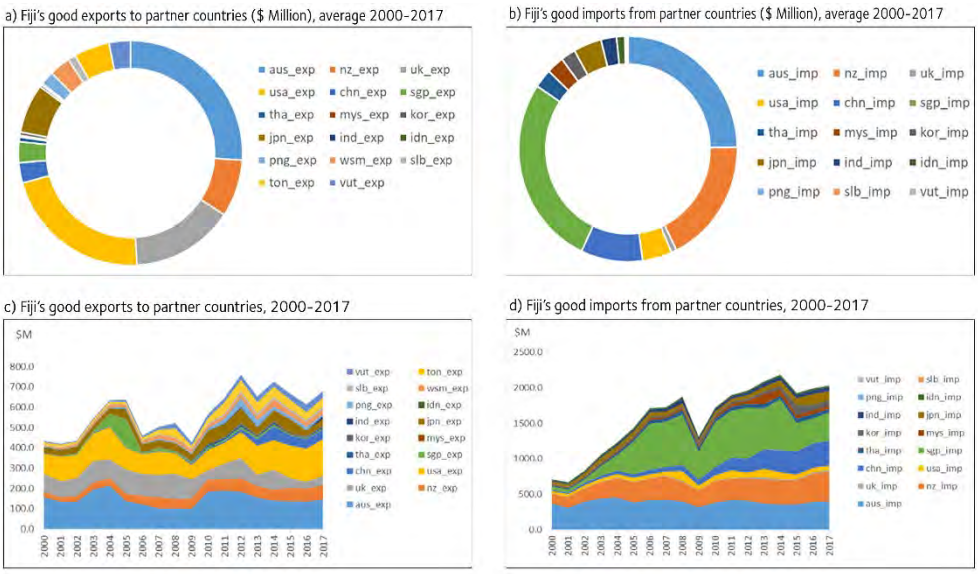
In line with global trends, fixed telephone subscriptions in PICs lag far behind mobile subscriptions, demonstrating the shift in preference towards wireless technologies. Fixed telephone subscriptions in Fiji fell from 16.0 subscriptions per 100 people in 2009 to around 8.0 subscriptions per 100 people in 2013, before levelling off. Tonga noted a rise in mobile subscriptions in 2013 but dropped afterwards. For the rest of the PICs—Western Samoa, Vanuatu, Solomon Islands and PNG—fixed telephone subscriptions have been negligible.

Furthermore, individuals using the Internet increased steadily but at varying rates across PICs. Fiji leads the region with the highest rate of Internet users at 50 percent in 2017, followed by Tonga (41 percent), Western Samoa (33 percent), Vanuatu (25 percent), Solomon Islands (11 percent), and PNG (11 percent), respectively. Fixed broadband subscriptions remain the preferred option for offloading mobile cellular traffic and meeting the demands of heavy data usage associated with streaming services and video connections for work or education (International Telecommunication Union, 2020). Fixed broadband subscriptions in Fiji continued to lead compared to other PICs, although overall broadband subscriptions across the six PICs remain significantly low.

2.3 Bilateral trade patterns in the PICs

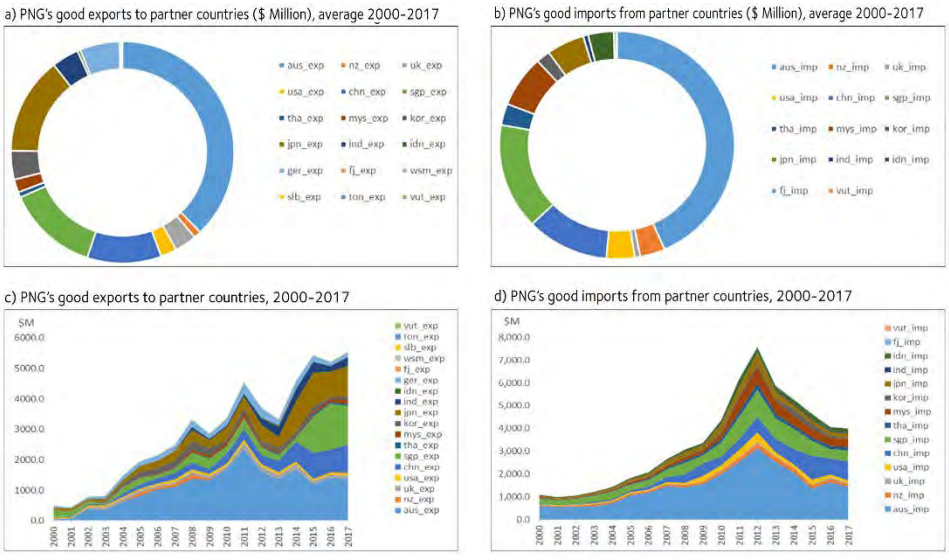
Notwithstanding the numerous economic shocks that occurred between 2000 and 2017, the PICs' bilateral trade pattern composition has grown significantly over the review period. Bilateral trade between the selected PICs has also increased with key trading partners such as the United States (US), United Kingdom (UK), Australia, New Zealand (NZ), and China. Fiji is one of the PICs' most important bilateral trading partners.

Figure 2: Trade composition of Fiji



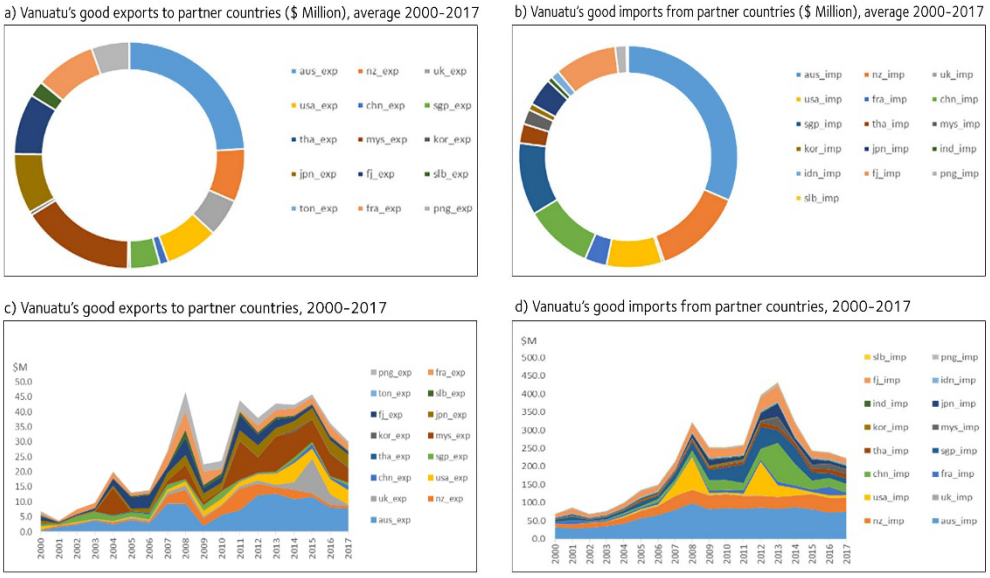
Looking at the individual PICs trade composition, Fiji's merchandise exports have been dismal due to several factors such as political unrest, global financial crisis, and natural disasters. Majority of Fiji's goods are exported to Australia, the US, UK, and NZ, whilst negligible for PICs. On the other hand, Fiji is heavily dependent on imports which are sourced largely from China, Singapore, Australia, NZ, and other Asian countries (Figure 2a).

Figure 3: Trade composition of Papua New Guinea



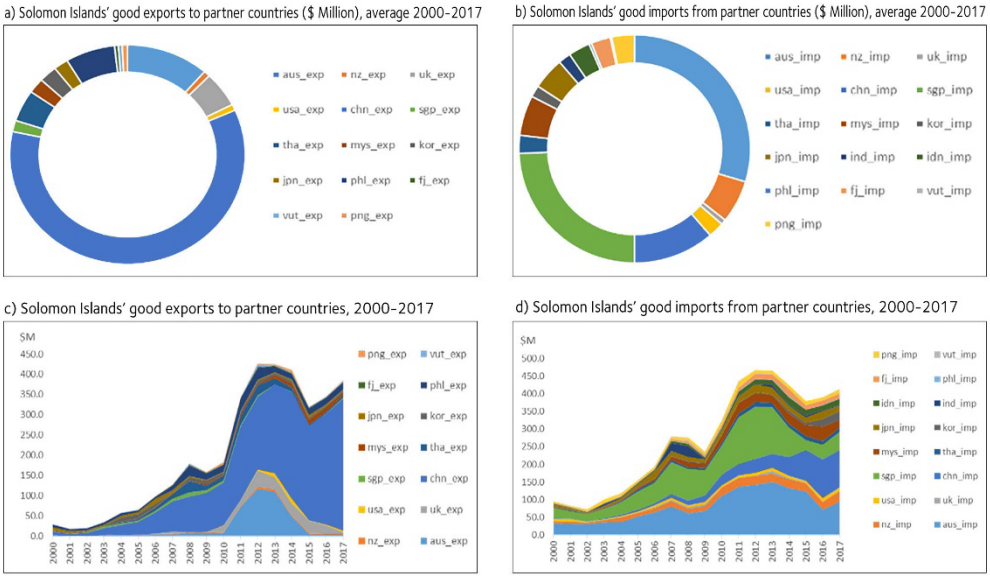
PNG's goods exports continue to rise, despite structural factors becoming more apparent in recent years. Export markets for PNG include mainly the countries of the Asia-Pacific Economic Cooperation,[5] Japan, Singapore, China, and Germany. Imports from PNG increased steadily after 2000, reached a peak in 2012, and fell gradually in the years leading up to 2017 (Figure 3a).

Figure 4: Trade composition of Vanuatu



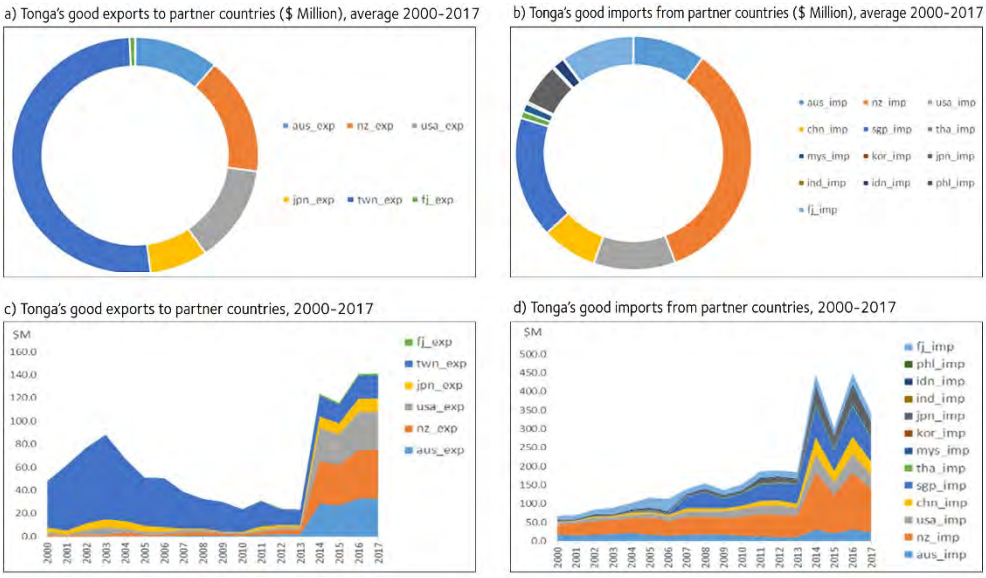
Between 2000 and 2017, Vanuatu's trade fluctuated because of political polarization, sluggish structural reforms while tourism activity helped to sustain economic growth. The major export markets include Australia, Malaysia, France, Fiji, and NZ; whilst NZ, Singapore, China, and Fiji are the primary import source countries (Figure 4a).

Figure 5: Trade composition of Solomon Islands



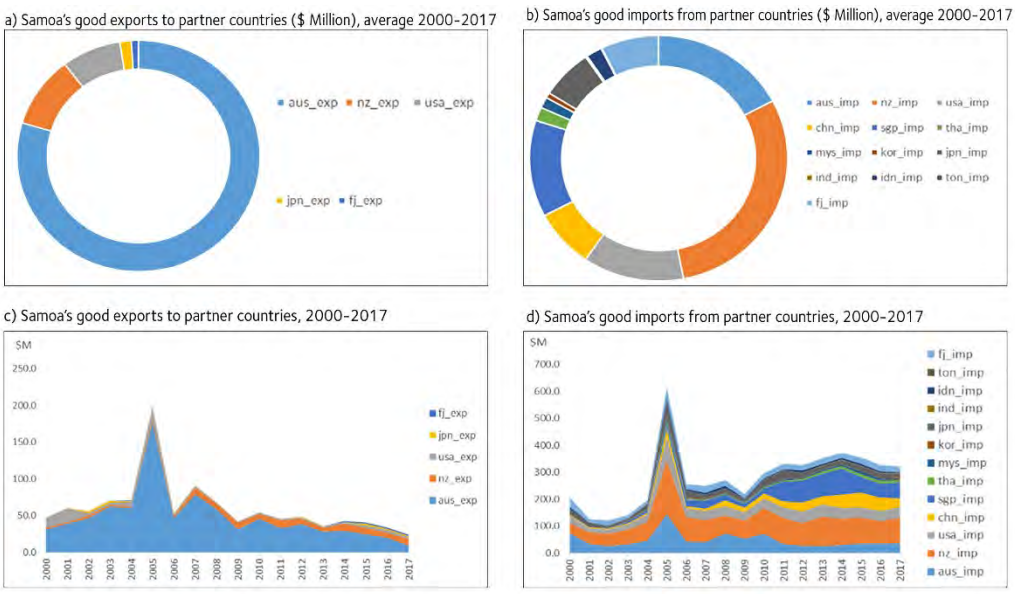
From 2000 to 2017, the Solomon Islands' exports and imports both increased mostly due to timber exports and trade relationship with China despite its civil unrest and natural disasters. Sixty percent of the Solomon Islands' exports are directed to China followed by Australia and the Philippines. Imports are sourced mainly from China, Singapore, NZ, and Malaysia (Figure 5a).

Figure 6: Trade composition of Tonga



Taiwan, NZ, US, Australia, and Japan make up most of Tonga's exports and imports markets. During the years 2000-2003, Tonga's exports increased, but then declined between 2010 and 2013, before rising to an all-time high on average between 2014 and 2017 (Figure 6a).

Figure 7: Trade composition of Western Samoa



Australia accounts for 80 percent of Western Samoa's exports, with NZ, the US and Japan also holding important share of export markets. Western Samoa imports goods primarily from

NZ, followed by Australia, US, Singapore, Fiji, and Japan. Exports from Western Samoa have been slow to pick up, reaching a high in 2005 and then declining until 2017 (Figure 7a).

Compared to the beginning of the digital technology momentum, trade composition has changed significantly since 2000, suggesting that PICs have adapted to the technological innovation, thus improving PICs value chain and flow of trade. Table A2 which provides an update of e-commerce markets in Fiji and PNG, shows annual growth in e-commerce revenues of 19.7 percent and 22.9 percent, respectively. E-commerce penetration users in Fiji is expected to grow by 35.2 percent in 2022 to 39.2 percent by 2025. E-commerce penetration users in PNG is expected to grow by 29.2 percent in 2022 and up to 37.8 percent by 2025.

3. Literature review

Previous studies have extensively examined the impact of ICT or digital technology on trade, for example Freund and Weinhold (2000, 2004); Ahmad et al. (2011); Chung et al. (2013); Biswas and Kennedy, (2016); Đokić, (2018); Nipo et al. (2018); Wang and Choi (2018); Luong and Nguyen (2020); and Ismail (2020).

ICT innovations holds the greatest potential to reach and connect firms around the global and domestic markets; overcoming significant geographical barriers and distance and forging closer trade ties (Abeliansky et al., 2021). For example, a 1 percent increase in ICT quality is associated with a 0.274 percent increase in bilateral trade. The use of innovative ICT technology encourages the diversification and creation of innovative products and services, space, and new information (Hanna, 2010); lowers barriers to entry in different market segments; and broadens the firm's consumer base (Freund & Weinhold, 2004b; Kiveu, 2013; Đokić, 2018; WTO, 2018; Lloyd & Kroeze, 2008).

3.1 Impact of ICT on productivity and trade costs

Literature has shown that ICT infrastructure and the adoption of innovative digital applications and solutions has increased productivity and resulted in lower trade costs. For example, Ahmad et al. (2011) find that ICT infrastructure (mobile and fixed-line phone subscribers, personal computers, and Internet users) have a significant impact on bilateral trade between Malaysia and its 36 trading partners. The observed countries data between 1980 and 2008 were derived from the Department of Statistic Malaysia (bilateral trade flows (exports); World Development Indicator—WDI of the World Bank (real GDP, endowment, exchange rate, dummy variables, infrastructure—mobile and fixed-line telephone subscribers, personal computers, and Internet users per 100 people); and Centre d'Etudes Prospectives et d'Informations Internationales—CEPII (distance). The authors applied the gravity model which has been widely used to empirically assess the impact of ICT infrastructure on trade flows. The gravity model has been estimated using the pooled Ordinary Least Square (OLS), Random Effects Model (REM), and Fixed Effects Model (FEM). The findings show that Internet has the least impact on trade than mobile and fixed-line telephone subscribers. The paper suggests that improving the quality of ICT infrastructure is important to enhance access to global markets and raise the competitiveness of exports.

In a similar vein, Ozcan (2018) examined whether the level of ICT contributes positively and substantially to Turkish trade between 2000 and 2014. Data were sourced from the International Monetary Fund (IMF) International Financial Statistics (IFS) (bilateral merchandise imports and exports); WDI (population); the World Trade Organization and Regional Trade Agreement (dummy variables, CEPII GeoDist Dataset and Gravity Dataset); and the International Telecommunication Union (ITU) (ICT variables and ICT development index (IDI) such as ICT access and ICT use). He finds that the development of ICT in Turkey and its trading partners have a trade-enhancing effect by reducing trade costs such as transportation, market entry, communication, and knowledge.

Furthermore, Wang et al. (2017) analysed the impact of cross-border e-commerce on trade in all the Chinese provinces excluding Hong Kong, Macao, and Taiwan. Data from 2011 to 2015 were taken from China's Foreign Trade and Economic Social Development Database, the National Bureau of Statistics, the Provincial Bureau of Statistics, the Provincial Department of Commerce, and the China E-Commerce Research Center. The authors estimated the gravity model using OLS and General Method of Moments (GMM) and show that cross-border e-commerce in the belt and road provinces has contributed more to the

growth of international trade than in non-belt and road provinces. The favourable outcome can be attributed in part to China's favourable cross-border e-commerce policies which led to lower transaction costs and increased global trade.

Freund and Weinhold (2004) explored whether Internet stimulates trade in Latin American countries (Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Dominican Republic Ecuador El Salvador, Guatemala, Honduras, Panama, Paraguay, Peru, Uruguay and Venezuela) between 1997 and 1999. Data were sourced from IMF (bilateral merchandise trade flows, GDP, and population); Direct-Line Distances (1986) (geographical distance between countries); and Rand McNally Historical Atlas of the World (1994) (common linguistic heritage and colonial links). Using the gravity model, the author's find that a ten percent increase in the growth of web hosting in a country result in a 0.2 percent increase in export growth. From 1997 to 1999, the Internet contributed about a 1 percentage point increase in annual export growth for the average country in the study sample. The evidence suggests that the Internet reduces the market-specific fixed costs of trade which in turn boost exports and improves competition.

Apart from examining the ICT infrastructure, Yushkova (2013) investigate whether ICT users contribute to the reduction of trade costs on the export flows of 40 countries (the Organization for Economic Co-operation and Development (OECD) plus Brazil, China, India, Indonesia, Russia, and South Africa). Data were taken from the OECD STAN Bilateral Trade Database by Industry and End-use Category (BTDIxE) (total goods exports); WDI (national accounts data); OECD National Accounts (GDP); CEPII (geographical distance between countries and distance dummies); World Economic Forum (WEF) (business ICT use); and Institute Européen d'Administration des Affaires (INSEAD) (business Internet use). Using the gravity model, the authors find that the number of business Internet users has a positive correlation with their export levels.

In the manufacturing and service sectors, ICT has been a driver of marketing innovation (Spiezia, 2011). It has also fundamentally altered how goods and services are produced, distributed, and consumed (Đokić, 2018); and it facilitates new product development, bolstering international trade for new products, particularly digitizable products that penetrate different market segments as they are introduced in virtual global markets. According to Wang et al. (2022), trade in digitalized products is increasing, and China's exports are increasing as a result of lower trading costs and increased innovation enabled by the use of ICT. In a similar vein, Kiveu (2013) found that the use of mobile phones and computers offers numerous opportunities for Small and Medium Enterprises (SMEs) in Kenya in terms of markets, maintaining customer relationships, product promotion, market research, and facilitating online financial transactions such as m-payments and mobile money transfer.

3.2. Impact of ICT on innovation chains and trade flows

In trying to assert whether ICT positively affect supply and innovation chains, Chung et al., (2013) examined the impact of ICT on bilateral trade of fruit and vegetables between 21 member Asian-Pacific Economic Cooperation (APEC) economies. The empirical data used were from 1997 to 2006, extracted from the UN Comtrade database (bilateral trade values of fruit and vegetables), ITU (2008) (ICT indicators such as access to Internet, mobile telephone, and fixed-line telephone, and population), and United Nations Conference on Trade and Development (UNCTAD) (2009b) (GDP). Results from the gravity model indicate that the two digital ICT (mobile telephone and Internet) has a positive impact on exports of fruit and vegetables and reduced communication costs while effect of mobile telephones has no significant effects on trade. The strongest positive impact was discerned for the traditional form of ICT, fixed telephone lines, in the export sector. The low to negligible digital ICT effect on the trade in fresh fruit and vegetables suggests that, during the study period, either these enterprises were still learning how best to capture the benefits of digital ICT for their

businesses or that the control of the large international supermarket chains now dominate the value chain in fresh fruit and vegetables to such an extent that the firms in the export sector are necessarily highly developed and large.

Xing (2018) examined how Internet and e-commerce adoption could positively impact bilateral trade flows and market access among 21 developing and least-developed economies and 30 OECD members. Data were sourced from the OECD STAN BTDIxE (trade); CEPII (distance, contiguous, language, colony); WDI (2013-2014) (telephone, cellphone, broadband, Internet security, market size); and INSEAD, Global Information Technology Report 2014-2015, WEF (extent of B2B Internet use in country). Using the augmented gravity model with FEM to estimate the equation, he finds that the use of e-commerce applications and greater access to modern ICT (such as telephone/mobile phone/broadband subscriptions) have a positive impact on bilateral trade flows. The author suggests that high-speed Internet access and secure servers are important for developing and least-developed countries to realize their full e-trade potential.

Additionally, Márquez-Ramos & Martnez-Zarzoso (2009) covered a sample of 13 exporters and 77 importers in 2000 from higher to lower income levels to examine the relationship between technological innovation and international trade. Data used were from the WDI (2005) for income, Feenstra, Lipsey , Deng, Ma, & Mo (2005) for bilateral trade by commodity, World Intergrated Trade Solution (WITS) for tariffs, transport costs by the World Bank, CEPII for distance between capitals, common official language and the colonial dummy, technological achievement index (TAI) for technological innovations by the United Nations Development Programme (UNDP) (2001). Using the gravity equation specified by Bergstrand (1985, 1989) and Deardorff (1995), the OLS, Pseudo Poisson Maximum Likelihood (PPML) and Harvey methodologies were used to estimate the gravity model. The study finds that technological innovation promotes international trade in all countries. Specifically, technological advances by technological leaders and potential leaders magnify the impact of innovation on exports, while countries with moderate innovation diffusion have lower exports. Regardless of the income group, several technological dimensions have a non-linear relationship.

The use of innovative ICT technology encourages firm to provide innovative quality products while broadening their consumer base. Lapatinas (2019) studied the impact of Internet on the economic sophisatication for a sample of 100 developed and developing countries over the period 2004 to 2015. The author used the Economic Complexity Index as a measure of economic sophistication, which also captures the diversity of a country's export products. For the explanatory variable, the log of Internet users ratio was chosen, including a number of control variables such as population density; education; GDP per capita; general government consumption to GDP; gross domestic investment to GDP; inflation and value added of agriculture to GDP. Results from the fixed effect (2SLS) and Arellano-Bond GMM model revealed the positive and significant effect of Internet on the level of economic sophistication and productive capacity of countries.

Nipo et al. (2018) studied the impact of ICT on trade in 42 upper middle-income countries considered to have ICT and 21 low-income countries (ICT have-nots) from 2007 to 2014. The data set included the following variables: merchandise trade (percent of GDP) and service trade (percent of GDP) as dependent variables; three ICT development indicators as independent variables—fixed telephone subscriptions (per 100 people), mobile cellular subscriptions (per 100 people), and Internet users (per 100 people); and a set of control factors—GDP per capita, population share, and domestic credit to the private sector (percent of GDP). Empirical findings from dynamic panel estimation techniques (OLS and GMM) revealed that the impact of ICT on trade is negligible in low-income countries, whereas mobile cellular subscriptions and Internet users had a positive impact on trade activities in middle-income countries. The findings highlight the current digital divide, as low-income countries

continue to rely on traditional forms of ICT, such as telephones, to facilitate trade, with limited access to advanced ICTs due to high costs and a lack of supporting infrastructure. As a result, the study suggests that policies aimed at promoting competition in the ICT sector, lowering costs, removing barriers to access, including improving infrastructure quality, and investing in human capital can help countries realize the full potential of digital technologies.

Demirkan et al. (2009) examined the bilateral trade flows and geographic distance data for 175 different countries to determine if physical and cultural distance matter in how ICT affects bilateral trade flows. The 2005 cross-sectional data for this study were from multiple sources: U.N. Commodity Trade Statistics Database (bilateral trade flows); U.N. Statistics Division (Internet usage, GDP); CEPII (geodesic distance variables including the dummy variables such as a shared common border, language, colonizer or historical colonial link). The authors apply the gravity model and find that bilateral trade flows were higher in countries with higher Internet use, indicating that the development of a common digital infrastructure across countries will increase their trade. They also observed that ICT use has greater impact on bilateral trade flows between major countries than on smaller countries. Finally, ICT use by more distant trading partners tend to yield more positive trade flows compared to countries closer to one another.

In similar studies, Mehmood and Malik (2021) investigated the impact of ICTs on international trade in eight Asia-Pacific economies between 2007 and 2018. The information used came from the UN Comtrade database (export values); and IDI comprising of (ICT access, ICT use, and ICT skills) created by ITU in 2008. The findings of the gravity model demonstrates that a higher level of ICT endowment in one trading country primarily increases international trade with other ICT-developing countries. Further to that, trade flows between countries are inversely related to distance and are directly linked to economic mass. ICT infrastructure investment is essential for achieving common standards and cybersecurity, and thus facilitating ICT-based trade between Asia-Pacific countries.

4. Data methods

4.1 Data description

In this study, we examine the impact of ICT on PICs trade using data from 2000 to 2017. The choice of countries and the study period are based on availability of data. Our study explores data on trade, economic growth, and other information for six PICs, including Fiji, PNG, Vanuatu, Samoa, Solomon Islands, and Tonga (Figures 2-7) which were sourced from the WDI database; International Monetary Fund—the Direction of Trade Statistics; and CEPII database.

Table 1 describes all variables used in this study. Similar to studies by Ahmad et al., 2011; Chung et. al., 2013; Márquez-Ramos & Martnez-Zarzoso, 2009, we use merchandise value of exports for each PICs to trading partners as the dependent variable, which were taken from the IMF Direction of Trade Statistics. The main independent variables cover (i) ICT access comprising of mobile cellular subscriptions and fixed telephone subscriptions and (ii) ICT use measured by individuals using the internet and fixed broadband subscriptions. Following Freund and Weinhold, 2004; Yushkova, 2013; Demirkan et al., 2009; Yi, Yean, & Ann, 2021; Ismail, 2020; Ozcan, 2018; Abeliansky, et al., 2021, bilateral trade flows between countries are positively influenced by their market size. As a proxy, we include real GDP (constant 2015 US$) of the six PICs and their trading partners accessed from the WDI. As suggested by Ozcan, 2018; Abeliansky, et al., 2021; Ismail, 2020; countries trade more with less distant countries due to lower transportation costs, our paper thus considers the geographical distance between the most populated city of each country measured in kilometers, drawn from the CEPII. Following previous studies (e.g., Yi, Yean, & Ann, 2021; Ismail, 2020), we include colonial ties and common language to capture trade costs, which were extracted from CEPII. It is expected that when countries share a common language, it lowers information loss or friction and therefore reduces search cost in trade (Lendle, et al., 2012).

Table 1: Variable description

Variable	Description
log(export)	The natural logarithm of good exports from host country to partner countries
log(TP_GDP)	The natural logarithm of Gross Domestic Products of trade partners
log(host_GDP)	The natural logarithm of Gross Domestic Products of host country
log(distance)	The natural logarithm of distance from host country to trade partners
language	Dummy variable; = 1 if countries speak English or 0 otherwise
col_ties	Dummy variable; = 1 if countries share colonial ties or 0 otherwise
mobile rate	The rate of mobile cellular subscriptions per 100 people
fixed phone rate	The rate of fixed telephone subscriptions per 100 people
Internet rate	The rate of individuals using the Internet, calculated by percentage of population
fixed broadband rate	The rate of fixed broadband subscriptions per 100 people
High mobile rate	Dummy variable; = 1 if mobile rate is greater than mean value, = 0 otherwise
High fixed phone rate	Dummy variable; = 1 if fixed phone rate is greater than mean value, = 0 otherwise
High Internet rate	Dummy variable; = 1 if Internet rate is greater than mean value, = 0 otherwise
High fixed broadband rate	Dummy variable; = 1 if fixed broadband rate is greater than mean value, = 0 otherwise

4.2 Descriptive statistics

Table 2 presents the descriptive statistics of selected variables included in the empirical models. The average log exports are low in the PICs compared to the mean of mobile rate, log (TP_GDP), and Internet rate. Maximum good exports are 7.76, while the minimum exports are negative 13.81.

In terms of ICT variables, there is significant variation across the six PICs. Mobile rate exhibited the greatest standard deviation (SD) variance, with some PICs having high mobile rate subscriptions than others. For instance, access to mobile phones range within a minimum of 0.14 subscriptions per 100 people to a maximum of 119.74 subscriptions per 100 people. Large variances were also observed for fixed phone rate and Internet rate.

The average mobile rate is 37.27 subscriptions per 100 people, followed by Internet which is 10.90 percent of population, fixed phones which is 6.86 subscriptions per 100 people, and fixed broadband rate which is 0.59 subscriptions per 100 people. There are no discernible patterns or uniformity in the data distribution. The SD for mobile rate, log (host GDP), distance, and log (TP GDP) deviated from the mean the most. Closer to the mean were language, fixed broadband rates, Internet rate, log (export), colonial ties, and fixed phone rates.

Table 2: Summary statistics

Variable	Obs. [1]	Mean [2]	Std. Dev [3]	Min [4]	Max [5]
log(export)	1,350	1.264	2.819	-13.816	7.764
log(TP_GDP)	1,710	12.479	2.982	5.885	16.759
log(host_GDP)	1,710	7.412	1.296	5.885	10.074
log(distance)	1,710	8.564	0.774	6.614	9.702
language	1,710	0.600	0.490	0.000	1.000
col_ties	1,710	0.084	0.278	0.000	1.000
mobile rate	1,710	37.273	32.857	0.146	119.749
fixed phone rate	1,710	6.860	7.024	0.881	30.461
Internet rate	1,710	10.906	12.062	0.469	49.966
fixed broadband rate	1,710	0.590	0.737	0.008	2.966

This table presents summary statistics. Column [1] shows number of observations, followed by columns [2] and [3] showing mean values and standard deviation, respectively. Columns [4] and [5] present min and max values.

4.3 Methods

4.3.1 Model selection

We follow the literature and apply an augmented gravity model to examine the impact of digital technology (ICT_{ijt}) on trade (lnY_{ijt}) in selected PICs, for example, Ismail, 2020; Yi, Yean, & Ann, 2021; Ozcan, 2018. A baseline regression model is presented in Equation (1) as follows:

$$lnY_{ijt} = \beta_0 + \beta_1 \ln(TP\_GDP)_{ijt} + \beta_2 \ln(host\_GDP)_{ijt} + \beta_3 \ln(distance)_{ijt} + \beta_4 lang_{ij} + \beta_5 col\_ties_{ijt} + \beta_6 ICT_{ijt} + \theta_{ijt} \quad (1)$$

where lnY_{ijt} is the dependent variable, measured by the natural logarithm of good exports from host country *(i)* to partner countries *(j)* in year *(t)*; β_1 and β_2 are coefficients capturing the impacts of trade partner's GDP and host country's GDP on export, respectively; β_3, β_4 and β_5 are coefficients measuring the relationships between control variables—including distance from host country to partner country, language, and colonial ties—and export, correspondingly. Noticeably, β_6 demonstrates the coefficient of how our key independent variable ICT_{ijt} affects

dependent variable lnY_{ijt}. Further, θ_{ijt} demonstrates the effects of time, exporter and importer fixed effects captured in our model; β_0 is intercept or constant term.

In this study, random-effect models are used to estimate the relationship between ICT and trade for two reasons. First, following literature (Ismail, 2020; Luong et al., 2019), we use random-effects model to examine the impacts of ICT on trade in PICs. According to Luong et al. (2019), if individual effects of the countries are random and not correlated with independent variables, REM will be more effective over FEM as this approach considers the residual of each entity as a new explanatory variable that allows us to estimate time-invariant factors. The main problem of FEM is that the variables that do not change over time, such as language, distance, among others, cannot be estimated directly in this model. Hence, REM is selected to address the issue.

Second, we also conduct Hausman test to provide evidence of model selection. The Hausman test is utilised to compare the random effects estimator to the 'within' estimator, particularly comparing the parameters for the models with fixed (β_{FE}) and random effects (β_{RE}). The null hypothesis is that $H_0: \beta_{FE} = \beta_{RE}$. If we cannot reject H_0, the fixed and random effects estimators are consistent, thus the random effects estimator is more favoured because of its more efficiency. If H_0 is rejected, the fixed effects estimator is the only consistent and must be selected.

The Hausman statistic is distributed as χ^2 and is computed as shown in Equation (2) below:

$$H = (\beta_c - \beta_e)'(V_c - V_e)^{-1}(\beta_c - \beta_e) \quad (2)$$

where β_c is the coefficient vector from the consistent estimator; β_e is the coefficient vector from the efficient estimator; V_c is the covariance matrix of consistent estimator; V_e is the covariance matrix of the efficient estimator.[6]

4.3.2 Equations

As digital technology is our main variable of interest, we measure ICT using four variables including mobile rate, fixed phone rate, Internet rate, and fixed broadband rate, as shown in Table 1. Therefore, Equation (1) is further demonstrated as follows:

(i) Impact of ICT, measured by mobile rate, on trade:

$$lnY_{ijt} = \propto_0 + \propto_1 \ln(TP\_GDP)_{ijt} + \propto_2 \ln(host\_GDP)_{ijt} + \propto_3 \ln(distance)_{ijt} + \propto_4 lang_{ij} + \propto_5 col\_ties_{ijt} + \propto_6 mobile_{ijt} + \theta_{ijt} \quad (3)$$

(ii) Impact of ICT, measured by fixed phone rate, on trade:

$$lnY_{ijt} = \gamma_0 + \gamma_1 \ln(TP\_GDP)_{ijt} + \gamma_2 \ln(host\_GDP)_{ijt} + \gamma_3 \ln(distance)_{ijt} + \gamma_4 lang_{ij} + \gamma_5 col\_ties_{ijt} + \gamma_6 fixed\ phone_{ijt} + \theta_{ijt} \quad (4)$$

(iii) Impact of ICT, measured by Internet rate, on trade:

$$lnY_{ijt} = \delta_0 + \delta_1 \ln(TP_{GDP})_{ijt} + \delta_2 \ln(host_{GDP})_{ijt} + \delta_3 \ln(distance)_{ijt} + \delta_4 lang_{ij} + \delta_5 col_{ties_{ijt}} + \delta_6 Internet_{ijt} + \theta_{ijt} \quad (5)$$

(iv) Impact of ICT, measured by fixed broadband rate, on trade:

$$lnY_{ijt} = \varepsilon_0 + \varepsilon_1 \ln(TP\_GDP)_{ijt} + \varepsilon_2 \ln(host\_GDP)_{ijt} + \varepsilon_3 \ln(distance)_{ijt} + \varepsilon_4 lang_{ij} + \varepsilon_5 col\_ties_{ijt} + \varepsilon_6 broad\ band_{ijt} + \theta_{ijt} \quad (6)$$

where variables $\propto_6, \gamma_6, \delta_6$ and ε_6 demonstrate the coefficients of the impacts of mobile rate, fixed phone rate, Internet rate, and fixed broadband rate on dependent variable lnY_{ijt}.

5. Empirical results and discussion

Table 3 presents results from our baseline models. Columns 1 to 5 show the estimated coefficients with goods exports to partner countries as the dependent variable and ICT as measured by mobile rate, fixed phone rate, Internet rate and fixed broadband rate as the variables of interest. We estimate separately the trade-enhancing effect of each ICT variable in Columns 1 to 4, while the combined results are shown in Column 5.

We find mixed results on the impact of ICT variables on goods exports of the six PICs to partner countries. Mobile rate has a negative and insignificant effect on goods exports, as shown in Column [1]. We try to ascertain some possible reasons for this: First, within the six PICs, there is significant variation in the development of the local mobile markets, with mobile subscriber rate ranging from a high of 63.9 percent in Fiji to a low of 19.6 percent in PNG, on average over the period 2000 to 2017. Second, the development of advanced ICT, supporting infrastructure (e.g., electricity) and innovative ecosystems to facilitate trade is often lacking given the substantial costs incurred due to geographical isolation and dispersion of many islands in the PICs. Moreover, PICs lack access to reliable, fast, and affordable Internet connectivity resulting in low mobile broadband penetration and hinders them from fully achieving the gains from digital trade and services such as e-commerce. Apart from this, internet connectivity via submarine cables and satellites in PICs is prone to disruption from frequent natural disasters.

We also find a negative and significant association between goods exports and fixed landline phone rate, shown in Column [2], suggesting that a 1 percent increase of fixed phone rate lowers goods exports to partner countries by 0.082 percent, although the estimated coefficient is negligible. A plausible explanation for this is that most firms and consumers have shifted away from the traditional fixed landline telephones towards wireless technologies and internet to facilitate trade transactions such as information searching, expanding markets and consumer base, product innovation and diversifying supply chain.

On the other hand, advanced forms of ICT, namely internet and fixed broadband rates have a positive influence on goods exports in the six PICs, consistent with previous studies (Freund and Weinhold, 2004; Clarke and Wallsten, 2007; Vemuri and Siddiqi, 2009; Demirkan, et al., 2009; Ahmad et al., 2011; Kneller and Timmis, 2016; Xing, 2018; Ismail and Mahyiddeen, 2018; Wang and Choi, 2019; and Lapatinas, 2019). Among the ICT variables, fixed broadband has the largest positive impact, whereby holding all other things constant, a 1 percent increase in fixed broadband rate boost goods export to partner countries by 0.253 percent.

Regarding control variables, both trading partners and host country's GDP estimated coefficients are positive, shown in Columns [1] to [5]. However, only the host country GDP is statistically significant at the 5 percent and 1 percent significance levels. It can be explained that economic expansion in host country leads to an improvement in infrastructure capacity and the ability of PICs to value add to production and therefore boost goods export. Favorable economic performance of trading partners is also crucial for PICs as it would mean more demand for merchandise exports of PICs.

The inverse and significant coefficient for distance confirms past studies which show that trade diminish with distance (Eaton & Kortum, 2002; Demirkan, et al., 2009). Geographic distance to trading partners is a common natural barrier faced by PICs, hence negatively affecting their bilateral trade due to high transport costs including development of ICT infrastructure. For example, among the six PICs, Tonga's distance to Australia is the furthest

at 3,585 kilometers, followed by Fiji at 3,224 kilometers, while Vanuatu is the closest at 2,476 kilometers. While ICT can help countries overcome challenges related to effective communication, distance plays a crucial role in limiting international trade, particularly for remote island economies (Demirkan, et al., 2009; Becker, 2012).

The coefficient for the colonial tie dummy variable is positive and significant at the 1 percent significance level, implying that existence of former colonial powers raises goods export in PICs. Against our expectations, common language shared between countries has a negative and significant influence on goods export.

Table 3: Impacts of ICT on trade in PICs

Dependent variable: logarithm of goods export to partner countries					
	[1]	[2]	[3]	[4]	[5]
log(TP_GDP)	0.209	0.182	0.182	0.201	0.192
	(0.206)	(0.204)	(0.205)	(0.205)	(0.204)
log(host_GDP)	1.730**	2.043***	3.209***	2.726***	3.976***
	(0.693)	(0.628)	(0.987)	(0.761)	(1.133)
log(distance)	-2.341***	-2.341***	-2.341***	-2.341***	-2.341***
	(0.138)	(0.137)	(0.138)	(0.138)	(0.137)
language	-4.823**	-5.067***	-5.072***	- 4.894**	-4.981***
	(1.907)	(1.890)	(1.902)	(1.900)	(1.891)
col_ties	1.055***	1.055***	1.055***	1.055***	1.055***
	(0.335)	(0.332)	(0.334)	(0.334)	(0.332)
mobile rate	-0.004				-0.006
	(0.005)				(0.005)
fixed phone rate		-0.082***			-0.087***
		(0.020)			(0.020)
Internet rate			0.023*		0.021
			(0.014)		(0.015)
fixed broadband rate				0.253*	0.364**
				(0.139)	(0.142)
Year fixed effects	Yes	Yes	Yes	Yes	Yes
Exporter fixed effects	Yes	Yes	Yes	Yes	Yes
Importer fixed effects	Yes	Yes	Yes	Yes	Yes

This table presents the impacts of ICT on trade in PICs by cross country. Dependent variable is the logarithm of goods export to partner countries. Columns [1], [2], [3], and [4] show empirical results of impacts of mobile phone rate, fixed telephone rate, the use of Internet rate, and fixed broadband rate on trade, respectively. *, **, and *** denote significance at 10 percent, 5 percent and 1 percent, respectively. Cell values represent coefficients of single independent variables on dependent variable. Standard errors are in parentheses. Number of observations is 1,305. Year, exporter and importer fixed effects are included. All regressions include constant terms.

In Table 4, we further analyse the impacts of when the six PICs experienced high rates of mobile phones, fixed phones, Internet, and fixed broadband on export, using dummy variables as described in Table 1. For instance, for high mobile rate, a dummy variable is assigned a value of 1 if the mobile rate is greater than its mean value, and 0 if otherwise. The same process is carried out for the other ICT indicators.

Similar to results in Table 3, we find that the impact of each ICT variable on goods exports to partner countries are mixed. Against our expectations and findings of past studies, the estimated coefficient for mobile subscription rates is negative and statistically significant at the 5 percent and 1 percent significance levels. In contrast to results of past studies, we find

that high Internet rate reduces goods exports but is insignificant. The underlying reasons could be that although adoption of mobiles is increasing in PICs, poor network connectivity particularly in rural areas remains a key challenge given the inadequate ICT and supporting infrastructure, high costs due to the fragmented nature of the region and small economies of scale. On the other hand, the coefficients for fixed phone and fixed broadband subscriptions are positive and significant at the 5 percent and 10 percent significance levels, respectively.

Turning to the results of the control variables, economic expansion in both trading partner and host country boost goods exports, consistent with Yi, Yean, & Ann, 2021. However, only the host country GDP is significant at the 1 percent level. As expected, distance weighs negatively on goods exports of PICs to trading partners. For the dummy variables, only the coefficient for colonial tie is positive and significant at the 1 percent level. We find that the result for language is inconsistent with past studies by Lendle, et al., 2012; Yi, Yean, & Ann, 2021, who argue that sharing a common language lowers information loss and search trade costs among bilateral trading partners.

Table 4: Impacts of high ICT rates on trade in PICs

Dependent variable: logarithm of goods export to partner countries					
	[1]	[2]	[3]	[4]	[5]
log(TP_GDP)	0.205 (0.204)	0.213 (0.205)	0.198 (0.205)	0.199 (0.205)	0.222 (0.204)
log(host_GDP)	1.932*** (0.629)	1.758*** (0.634)	1.957*** (0.631)	1.991*** (0.632)	1.824*** (0.633)
log(distance)	-2.341*** (0.138)	-2.341*** (0.138)	-2.341*** (0.138)	-2.340*** (0.138)	-2.340*** (0.137)
language	-4.866** (1.895)	-4.788** (1.898)	-4.927** (1.902)	-4.912** (1.902)	-4.710** (1.894)
col_ties	1.055*** (0.333)	1.055*** (0.334)	1.055*** (0.335)	1.058*** (0.335)	1.059*** (0.333)
High mobile rate (Yes = 1)	-0.666*** (0.211)				-0.502** (0.238)
High fixed phone rate (Yes = 1)		0.843*** (0.319)			0.759** (0.351)
High Internet rate (Yes = 1)			-0.138 (0.170)		-0.122 (0.191)
High fixed broadband rate (Yes = 1)				0.182 (0.164)	0.283* (0.168)
Year fixed effects	Yes	Yes	Yes	Yes	Yes
Exporter fixed effects	Yes	Yes	Yes	Yes	Yes
Importer fixed effects	Yes	Yes	Yes	Yes	Yes
Hausman test	-113.68	-0.00	-42.58	-45.05	-12.12

This table presents the impacts of high ICT rates on trade in PICs by cross country. Dependent variable is the logarithm of goods export to partner countries. Columns [1], [2], [3], and [4] show empirical results of impacts of high mobile phone rate, high fixed telephone rate, high Internet rate, and high fixed broadband rate on trade, respectively. *, **, and *** denote significance at 10 percent, 5 percent and 1 percent, respectively. Cell values represent coefficients of single independent variables on dependent variable. Standard errors are in parentheses. Number of observations is 1,350. Year, exporter and importer fixed effects are included. All regressions include constant terms.

6. Conclusion

This study applies the augmented gravity model using REM regressions to assess the impact of digital technologies on trade in six PICs, covering Fiji, PNG, Solomon Islands, Vanuatu, Tonga, and Western Samoa from 2000 to 2017. In this regard, we examine key ICT variables namely mobile rate, fixed phone rate, Internet rate and fixed broadband rate and whether they enhance trade in the selected economies.

The study finds mixed results on the effects of ICT variables on the six PICs' goods exports. Advanced forms of ICT, such as the Internet and fixed broadband rates, help raise goods exports to partner countries in the six PICs. Against our expectations, both mobile rate and fixed telephone rate have a negative relationship with goods exports. The findings imply that despite the progress in ICT development in the six PICs, the digital divide in connecting the still unconnected populations remains a key challenge due to reasons such as inadequate ICT and supporting infrastructure, high costs due to the fragmented nature of the region, small economies of scale and gaps in ICT skills.

Therefore, digital technologies have the potential to spur trade relationships in the PICs and contribute to socioeconomic progress. To leverage on the untapped potential of digital technologies, we outline some policy suggestions below:

- First, strengthening investment in ICT to bridge the digital divide between rural and urban areas. Improving the quality of supporting infrastructure such as connecting households to reliable power supply is also a critical foundation of ICT development. To address the limited economies of scale and high investment costs, the PICs can continue to promote public private partnerships with the support of multilateral development partners;

- Second, developing digital skills and competencies, including digital literacy. For instance, innovation hubs can be used to facilitate peer learning, on the job training and to generate innovative business ideas; and

- Third, strengthening regulatory frameworks to adapt to evolving technologies. Rules and laws will need to protect users from cybercrimes and misuse of social media platforms.

These policy measures would help unleash the untapped benefits of digital technologies in PICs. High-speed Internet can lower the cost of doing business, enabling firms to expand market base and easily access information to support timely decision making. Moreover, electronic submission methods and customs-related document processing, can expedite trade processing, and therefore boost trade activities.

However, this study is limited due to availability of timely data, particularly on ICT indicators, including e-commerce statistics. Future research may explore additional aspects such as the role of ICT and trade policies, human capital, and financing in digital trade-related goods and services. It can also consider expanding the study period and to include other PICs.

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Notes

1 Digital trade today is the result of technological revolution and industrial change caused by informatization, digitization, and intelligent connectivity (Standing Committee of Wuhan Municipal Party, 2021).

2 An ICT-led trade cost reduction theory, according to Demirkan et al. (2009), tries to address four elements of costs (search, shipping, management and control, and time) that could be addressed so that more trade occurs between countries with higher ICT penetration levels, because trading with these partners should be less costly.

3 The Telecommunications Act (2009) allowed the Telecommunications Commission for the Solomon Islands to be established and for the sector to be liberalised. This led to the entry of B mobile Limited in 2010 and ended the monopoly of Solomon Telekom (United Nations Conference on Trade and Development, 2018).

4 In November 2000, Fiji became the first PIC to be connected to the Southern Cross undersea fibre-optic cable and has established itself as a regional hub.

5 APEC membership includes: Australia; Brunei Darussalam; Canada; Chile; People's Republic of China; Hong Kong, China; Indonesia; Japan; Republic of Korea; Malaysia; Mexico; NZ; PNG; Peru; the Philippines; the Russian Federation; Singapore; Chinese Taipei; Thailand; US; and Vietnam.

6 In Table 4, we show results from Hausman test in accordance with five models. Here the χ^2 statistic is negative. We might interpret this result as strong evidence that we cannot reject the null hypothesis. Such a result is not an unusual outcome for the Hausman test. Thus, random effects models are selected.

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