



# Information and Communications Technology and Goods Export Performance: Evidence for Cambodia

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## Abstract

This paper empirically examines the impact of ICT on Cambodia's goods export performance. ICT proxied by broadband, mobile phone and fixed phone penetrations, as well as the Internet use is introduced into the augmented gravity model with a panel data set from 1996 to 2017. Due to high multicollinearity among the included variables, each ICT variable is introduced into the model one by one. Estimation is carried out using the Hausman-Taylor method, which reduces or removes the correlation between the composite error terms and the included variables. ICT variables are found to be positively associated with Cambodia's goods exports. Based on the results, the Royal Government should give a high priority to further develop ICT infrastructure and continue to promote ICT uses in enhancing the competitiveness of Cambodia. Implications from this study, in particular the important roles of ICT in enhancing export performance, are of vital relevance to other developing countries, including Thailand where ICT infrastructure development and uses still need to be further enhanced and promoted to reap the full benefits of ICT in the age of an increasingly digitalizing world.

**Keywords:** Cambodia, ICT, Export Performance, Panel Data

**JEL Classifications:** C23, F14

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## 1. Introduction

The roles of information and communications technology (ICT) in enhancing international trade have attracted substantial attention from academics, policymakers and business leaders because ICT generates a positive impact on labor productivity, electronic commerce, trade flows, foreign direct investment, economic growth, and national development. ICT impact on international trade takes place through its contributions to build necessary infrastructure that supports trade flows among countries as the result of cost reduction in sending goods and services to different destinations round-the-clock and from anywhere. The advantages of ICT utilization include a sharp drop in transaction costs, reduced prices, increased sales, higher profits, and the expanded global market reach (Rahayu and Day, 2017). Fernandes et al. (2019) indicated that an access to ICT can reduce trade costs via the reduction in information and transaction costs. With ICT, exporting companies find it easier to get information about potential buyers and international markets, as well as to advertise their products globally, whereby they can establish international trade linkages with potential buyers. These can further enhance trade flows among countries.

In the age of increasing digitalization, international trade landscape is profoundly affected by ICT as it allows firms to expand their export markets globally. Recent studies have documented a positive linkage between ICT adoption and international trade. Freund and Weinhold (2002) examined the impact of the Internet use on bilateral services trade of 13 countries and 14 industries from 1995- to 1999 and found that the growth of web hosts, which were proxies for ICT, led to an increase in exports and imports of services. The positive linkages between trade in goods and the Internet use is also found by Freund and Weinhold (2004) who examined the role of Internet adoption in boosting bilateral trade flows in goods for a sample of 56 countries between 1997 and 1999. Their results suggest that the Internet has a significant positive impact on export growth. Tang (2006) studied the effect of telecommunications on U.S. imports of differentiated goods over the period of 1975-2000. He found, using the fixed-effects model, that the adoption of fixed phones, mobile phones, and Internet connections in the exporting countries have a positive and significant impact on the U.S. imports of differentiated goods from its trading partners over the period under investigation.

The landscape of Cambodia's ICT sector has been shaped by the Royal Government of Cambodia (RGC)'s policy to liberalize the sector and the ongoing development of networks and telecommunications services. Thanks to the continued improvements in technology infrastructure in Cambodia, the country's online commercial transactions have increased as the result of the emergence of a middle class, a large pool of young people with a strong desire for IT, the availability and adoption of smartphones and other electronic devices, the latest technologies, and low-cost mobile data in prepaid contracts, as well as the RGC's policy to promote the ICT sector and its applications. However, the effects of ICT on Cambodia's international trade have not yet been well studied. Thus, it merits an investigation into its role in facilitating international trade for Cambodia. This paper, therefore, aims to examine the effects of ICT on Cambodia's exports of goods. Its findings should offer some policy implications for the Kingdom and those with a similar ICT and economic developments.

This present paper makes the following contributions to the literature on the ICT-trade nexus in developing countries where ICT developments are often at infancy stage. First, the use of ICT in Cambodia has increased rapidly, thanks to the Royal

Government of Cambodia's policy to promote the ICT sector and also to the reasonably-fast Internet available at a low cost. However, no research was conducted to examine the relationship between ICT and Cambodia's commercial activities. Second, in contrast to many previous studies that looked at only the effect of the Internet on trade, this paper uses a set of different aspects of ICT to test their individual effects on Cambodia's export performance. Finally, also contrary to previous studies that used a fixed-effects model to address the heterogeneity bias, this current > present study employs the Hausman-Taylor method that provides consistent estimates of both time-varying and time-constant explanatory variables (McPherson and Trumbull, 2008; Wooldridge, 2010; Greene, 2012).

The paper is organized as follows. Section 2 provides a brief overview of the developments of ICT sector in Cambodia. Section 3 reviews related literature on the nexus of ICT and trade upon which the econometric specification is based in order to investigate the impact of ICT on international trade for Cambodia. Section 4 presents the econometric specification, data and estimation techniques. Section 5 reports estimation results and discussion. Section 6 concludes and offers policy implications.

## **2. Stylized Facts of ICT Developments in Cambodia**

ICT has played an increasing role in economic development, in particular transforming the traditional economy into the digital one.<sup>1</sup> Countries with more developed ICT tend to enjoy its advantages and achieve higher economic prosperity through cost advantages, faster business communications, and round-the-clock commercial transactions. There are several public organizations responsible for the development of ICT infrastructures to promote the digitalization of the Cambodian economy, including electronic commerce and online business transactions. These include the Ministry of Post and Telecommunications (MPTC), the Telecommunications Regulator of Cambodia (TRC), and the National ICT Development Agency (NIDA) which was integrated into the MPTC in 2013.

The MPTC is charged with developing and executing policies and strategies related to telecommunications. MPTC responsibilities are to propose legislation to be approved by the legislative body, lead and oversee the telecommunications and ICT sector, formulate relevant policies on networks, communications services and online transactions, as well as promote competition in the telecommunications sector. In its Cambodia Rapid e-Trade Readiness Assessment, United Nations Conference on Trade and Development (2017) indicated that an increasing number of Cambodian people acknowledged electronic transactions including e-banking and other related services. The World Bank (2017) reported that 21.67 percent of Cambodians had bank accounts in 2017, increased from 3.66 percent in 2011. ICT technology has also been introduced in the tourism sector in Cambodia.

NIDA was established in 2000 to develop and promote ICT technology. Originally under the Office of the Council of Ministers, it was integrated into the MPTC in 2013 to improve public service delivery, efficiency, and effectiveness as its ICT policy responsibilities overlapped with those of MPTC. TRC, officially established in late 2012 to formulate telecommunications policy and regulations, monitor telecommunications services; propose legal instruments; set standards for the use of telecommunications infrastructure and networks; promote competition; grant,

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<sup>1</sup> This section is drawn from Soeng et al. (2019).

suspend, transfer, and withdraw permits, certificates, or licenses; and act as a regulatory body and resolve disputes relating to the telecommunications sector.

Since the 1993 election, Cambodia has adopted an open policy towards foreign direct investment (FDI) and trade with the rest of the world. The investment law, drafted and approved in 1994, was amended in 2003 to further simplify investment application procedures and make approved investment projects eligible for generous fiscal incentives on a non-discriminatory basis. Cambodia received about US\$1.58 billion of total FDI in 2000. This amount increased to \$6.16 billion in 2010 and \$21.20 billion by the second quarter of 2018.<sup>2</sup> The distribution of FDI in Cambodia was uneven from 1994 to 2018. Based on data up to the second quarter of 2018, the financial sector attracted 23 percent of total FDI stocks, followed by labor-intensive manufacturing. Over the same period, FDI in telecommunications sector remained small, about 3 percent of total FDI stocks. This may pose some challenges for the development of ICT and other ICT-related sectors in Cambodia.

Since ICT is often viewed as a driving force for many aspects of the national economy, through promoting competitiveness, sustainable economic growth, and development in the age of digitalization, in 2016 the Royal Government of Cambodia implemented its Telecommunications and ICT Development Policy 2020 (Royal Government of Cambodia, 2016) to serve as a roadmap and mechanism for a successful development of the ICT sector. With this policy, Cambodia could continue to sustain high economic growth and equitable economic development in the digital age.

Based on its ICT policy, Cambodia envisages itself to become a competitive information-based society that can provide ICT-based solutions for transforming the country into a knowledge-based economy to enhance economic growth and development. To achieve this, the government is committed to achieving the following targets by 2020. First, it is improving and expanding the telecommunications infrastructure and the use of sector services by expanding broadband service coverage in urban and rural areas, as well as increasing the Internet penetration rate. By 2020, the government targets to increase broadband service coverage in urban areas to 100 percent, broadband service coverage in rural areas to 70 percent, the mobile penetration rate to 100 percent, the Internet penetration rate to 80 percent, the broadband Internet penetration rate to 70 percent, the percentage of households with Internet access to 30 percent, and the percentage of households with a-computers to 30 percent.

Second, the government is developing human resources and capacity in ICT skills by setting a target for 2020 to increase the percentage of government officials with basic ICT skills to 95 percent, the percentage of subnational government officials with basic ICT skills to 75 percent, and the percentage of high school graduates with basic ICT skills to 100 percent. Third, the government is committed to encouraging the expansion of the ICT industry and promoting ICT applications in all public institutions. It welcomes more investment in ICT and telecommunications as well as ICT-related companies. It encourages the intensive use of emails and the development of websites in all public institutions. To achieve the 2020 targets, the government formulates three broad strategies: (i) strengthening of telecommunications and ICT development, (ii) enhancement of ICT security and development of the ICT industry, and (iii) promotion of the use of ICT applications.

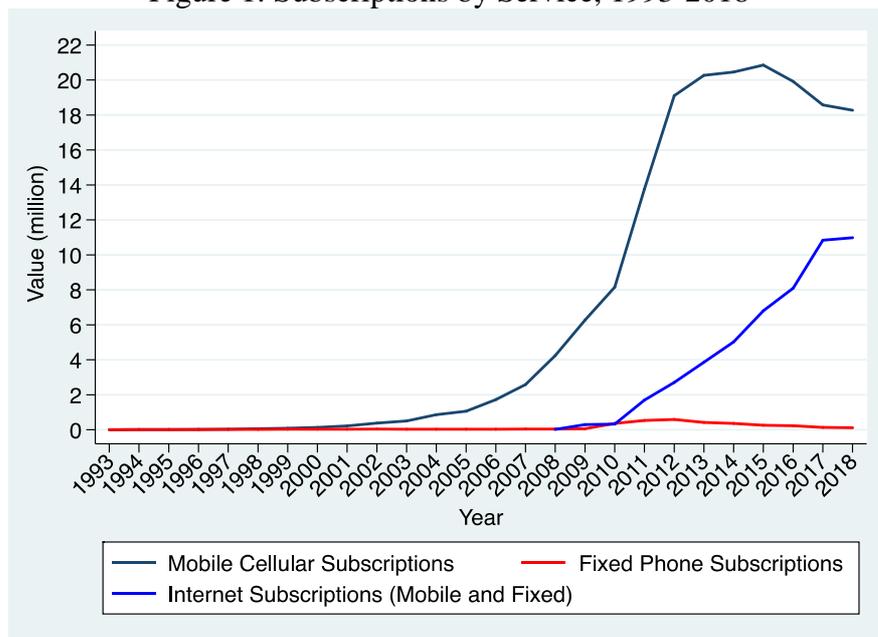
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<sup>2</sup> The amounts are FDI stocks in Cambodia, based on the data made available by the National Bank of Cambodia (2018).

ICT and its applications have great potential (United Nations Conference on Trade and Development, 2017). This is mainly because of the emergence of a middle class in urban areas, a large pool of young people with a strong desire for IT, the availability and adoption of smartphones and other electronic devices, the latest G5 technologies, and low-cost mobile data in prepaid contracts. Mobile Internet can be easily accessed at an affordable price through smartphones, tablets, and other devices. Measures to promote ICT are included in Cambodia’s National Strategic Development Plan 2014-2018 (Royal Government of Cambodia, 2014) and the Rectangular Strategy Phase IV (Royal Government of Cambodia, 2018).

According to the Ministry of Posts and Telecommunications (MPTC, 2019) and World Bank (2019), Cambodia had 20,402 Internet subscribers in 2008, increasing exponentially to 320,190 in 2010, 6.80 million in 2015, and 10.98 million in 2018 (Figure 1)<sup>3</sup>. This sharp increase in Internet use correlates with the rise in mobile cellular subscriptions from 4,810 in 1993 to 8.15 million in 2010 and 20.85 million in 2015, although this dropped to 19.92 million in 2016, to 18.57 million in 2017, and to 18.27 million in 2018 (MPTC, 2019; World Bank, 2019). Cambodians are using mobile Internet on their smartphones. Cambodia’s Telecommunications and ICT Development Policy 2020 estimates that 70 percent of the population will have regular Internet access by 2020.

Figure 1: Subscriptions by Service, 1993-2018



Source: MPTC (2019) and World Bank (2019)

Cambodia has 37 Internet service providers and 19 other Internet-related voice over Internet protocols (VoIPs) in operation (MPTC, 2018). Three large operators—Cambodia Fiber Optic Communication Network (CFOCN), Viettel Cambodia, and Telecom Cambodia—have established fiber optic backbone routes with a combined total length of 29,800 kilometres. In addition, submarine cables have been granted to Telcotech, Chuan Wei Cambodia, and CFOCN. Telcotech’s submarine cable has been in operation since March 2017, connecting Cambodia, Malaysia, and Thailand. CFOCN’s cable has been operated since the late 2017 and connects Cambodia to the Asia-Africa-Europe 1 submarine networks. This could help transform Cambodia into

<sup>3</sup> Figure for 2018 is based on data of April 2018.

a digital economy, although the level of digitization lags other advanced Association of Southeast Asian Nations (ASEAN) member states.

Despite the lack of formal competition legislation, Cambodia's telecommunications sector has experienced fierce competition, due largely to the relatively easy entry into the sector. In the mobile phone industry, prior to 2008, there were only four companies competing in Cambodia's telecom market (Vong, Lee, and Zo, 2012). Thanks to the continued expansion of market demand for telecommunications services, the number of phone operators doubled, reaching eight companies in 2010. Phong et al. (2016) reported almost half of the population (48%) had access to the Internet or Facebook, and five out of every six respondents had their own Facebook account. Some 85 percent of Facebook users accessed their Facebook through smartphones. In 2016, the Internet or Facebook became the most important information source. Almost one third of Cambodians did their reading on the Internet.

MPTC (2018) reported that as of February 2018, it had issued telecommunications licenses to 82 ICT operators, of which 37 (more than 45%) were Internet service providers and 19 (23%) were VoIPs. VoIP service covered the 24 provinces and major cities of Cambodia. Nine mobile phone operators and eight fixed telephone operators were active in the Cambodian telecommunications market. In November 2016, Viettel (Cambodia) enjoyed a market share of almost 46 percent in the mobile cellular market, followed by Smart Axiata at 40 percent and CamGSM at 13 percent. Similarly, in the fixed telephone market, Viettel (Cambodia) captured a market share of 73 percent, leaving the remainder to be shared by Telecom Cambodia at 14 percent and others at 13 percent. In the Internet market, Smart Axiata had a cellular Internet market share of about 60 percent, while Viettel (Cambodia) had 30 percent and CamGSM captured about 10 percent. For the fixed Internet market, Viettel was in the lead, enjoying a market share of more than 60 percent, followed by Cogetel (ONLINE) at 10.31 percent, Telecom Cambodia at 7.60 percent, and Xinwei (Cambodia) Telecom at 6.18 percent. Based on these market share figures, the market structure in the telecommunications sector seemed to be rather concentrated. Viettel enjoyed 46% and 73% in the mobile cellular and fixed phone markets respectively, while Smart Axiata captured 60% in cellular Internet market share in 2016.

### **3. Linkages between ICT and Trade: A Literature Survey**

Information and Communications Technology produces a remarkable effect on the economy at both micro and macro levels, thanks largely to the rapid development, the Internet and the availability of digital technologies. Studies at micro level show that ICT has a significant impact upon labor market, due largely to technological change toward skilled labor force. ICT is found to have increased the demand for skilled labor, which is largely responsible for the rising wage gap between the skilled and unskilled workers (Autor et al., 1998, 2003; Liu and Nath, 2013). Studies at macro level suggest that better ICT developments *ceteris paribus* lead to higher productivity and economic growth (Stiroh, 2002). Similar results are reported by Choi and Yi (2009) who find positive and significant impacts of the Internet uses on growth. Their results suggest that a one percentage point increase in the Internet users is positively associated with an increase in the growth rate of around 0.05 percentage point.

In the age of an increasing digitalization, trade flows are profoundly changed and reshaped by ICT-based innovations that give firms wider access to global markets, allowing them to expand their customer base, increase the scale of

production and raise profits (Xing, 2018). It also forces firms to compete with competitors, exposes them to new ideas and expertise, and encourages them to stay abreast of market trends, which may lead to boosting productivity and thus export increase. There are several channels through which ICT may induce international trade among countries (Liu and Nath, 2013). First, ICT could encourage exports as it may substantially reduce the fixed costs of entering a market, which include the costs of searching for necessary information about potential markets, as well as costs of establishing global distribution networks. Second, commercial transactions require a good planning to address uncertainties associated with possible delays in acquiring and transmitting relevant information. With the use of ICT applications, the delays can be reduced, which leads to the increase of trade flows between countries. Third, ICT facilitates trade through cost reduction in information search and communications, as well as time reduction in the transactions. Wong (2019) is perhaps the first to show the relationship between ICT and international trade. Based on import demand function and export supply function with a two-economy model, he shows theoretically that an increase in the degree of digitalization increases the volume of international trade between the two countries.<sup>4</sup>

Fernandes et al. (2019) indicate that ICT reduces trade costs as it allows export-oriented companies to learn more easily about foreign markets' regulatory requirements and goods prices; to find and interact with international buyers; and to maintain their relationships. ICT also helps firms to organize their production processes more efficiently and induces them to learn about new production techniques and technologies. A country's technology infrastructure plays a critical role in creating an environment conducive for ICT development and its adoption, which establishes the basis for developing and promoting the digital economy.

In recent empirical studies, the impact of ICT on international trade has been investigated and documented. Freund and Weinhold (2002) looked at the impact of the Internet use on bilateral trade in services over the period of 1995-1999 and found a significant positive association between the growth of web hosts and exports and imports of services. Freund and Weinhold (2004) further examined the role of Internet adoption in bilateral trade flows in goods. They found that a 10-percentage point increase in the adoption of Internet led to a 0.2 percentage point increase in trade in goods in a panel of 56 countries over the period of 1997-1999. Tang (2006) investigated how the use of different means of telecommunications affected US imports of differentiated goods from 1975 to 2000. Using the fixed-effects model, it was found that the adoption of fixed line telephones, mobile phones, and Internet connections in the exporting countries had a significant positive impact on the US imports of differentiated goods.

Similarly, Clarke and Wallsten (2006) found that greater Internet penetration promoted trade flows from developing countries to developed countries, but no significant effect was detected for the trade flows from developed countries to developing countries. In turn, Vemuri and Siddiqi (2009) found that Internet use was positively associated with bilateral trade for a panel of 64 countries between 1985 and 2005. Using a data set from more than 150 countries between 1990 and 2006, Choi (2010) indicated that a doubling of Internet usage would increase a country's export of services by between 2% and 4%. Likewise, Liu and Nath (2013) found that Internet subscriptions and Internet hosts were positively and significantly related to trade

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<sup>4</sup> For details, see Kar-yiu Wong, "e-commerce and international trade", in Chen, L. and Kimura, F. (eds.): *Developing the Digital Economy in ASEAN*, United Kingdom, Routledge, 2019.

performance. Yushkova (2014) used the business Internet usage index to estimate the effect of the Internet on exports of goods for 40 countries and found that the Internet usage by business communities in both exporting and importing country is positively related to the export flows between these countries. More recently, Lin (2015) find a positive and significant association between Internet uses and export growth, using data from 1990- to 2006 from for nearly 200 countries. Xing (2018) examined the impact of the Internet on bilateral trade, using a panel data set of 51 countries and found that better access to ICT boosted the bilateral trade flows among the countries under investigation.

#### 4. Specification, Data, and Estimation Techniques

The discussion above provides a brief review of the linkages between ICT and international trade flows. To investigate the impact of ICT on Cambodia’s goods exports, a panel data analysis is carried out. Based on the aforementioned brief discussion, the relationship between services export and information and communications technology in Cambodia is modelled as follows:

$$\begin{aligned} \ln EXPORT_{it} = & \beta_0 + \beta_1 \ln ICT_{it} + \beta_2 \ln POP_{it} + \beta_3 \ln GNICAP_{it} + \beta_4 FDI_{it} + \beta_5 \ln EXCH_{it} \\ & + \beta_6 TF + \beta_7 Border + \beta_8 GSP + \beta_9 ASEAN + \alpha_i + \varepsilon_{it} \end{aligned} \quad (1)$$

where  $i = 1, 2, 3, \dots, N$  and  $t = 1, 2, 3, \dots, T$  (1996 to 2017)

$\ln$  stands for a natural logarithm. The subscripts  $i$  and  $t$  refer to country and time, respectively.  $\alpha_i$  is individual country-specific, accounting for the unobserved heterogeneity among trading partners, and  $\varepsilon_{it}$  is the error term assumed to be well behaved. Specification (1) suggests that goods exports of Cambodia are influenced by information and communications technology (ICT); population of trading partners (POP); per-capita income of the trading partners (GNICAP); foreign direct investment (FDI); exchange rate (EXCH); trade freedom and a set of binary variables, namely Border, Generalized System of Preferences (GSP) and ASEAN, that may affect trade flows between Cambodia and its trading partners. The variable of interest, ICT, is proxied by fixed telephone subscriptions per 100 people; mobile cellular subscriptions per 100 people; fixed broadband subscriptions per 100 people; and Internet users as percentage of population.

The specification (1) is estimated by using a panel data set covering 84 trading partners of Cambodia during 1996-2017 (see Appendix A). Data for the dependent variable (goods exports) are the International Monetary Fund (IMF)’s Direction of Trade Statistics, while data on population and exchange rate are from the United Nations. GNI per capita are retrieved from the World Bank’s World Development Indicators. Trade Freedom is from the Heritage Foundation. GSP is from Cambodia’s Ministry of Commerce and the United Nations Conference on Trade and Development (UNCTAD). Data on ICT are taken from the World Bank’s World Development Indicators.

The use of panel data has several advantages (Hsiao, 2005, 2007; Plasmans, 2006). Plasmans (2006) has shown that panel data are more efficient with respect to random sampling and ease of identification, present less multicollinearity, and are better for aggregation as the aggregation may vary over time. Similarly, Hsiao (2005) has indicated that an important advantage of panel data is that it allows controls for the impact of omitted variables, and contains information on the intertemporal dynamics, and, moreover, that the individuality of the entities allows the effects of missing or omitted variables to be controlled for. The use of panel data takes into

account the diversity and the specificity of the unobservables, which are not shown in the above specification.

A panel data set allows the use of two estimation procedures, namely fixed-effects (FE) or random effects (RE) estimations. The FE estimator allows the unobservable country heterogeneity, and is always less efficient than the RE estimator, but the latter may suffer from endogeneity bias (Hausman test), so the FE estimator is preferred in that case. Like the FE model, RE estimations take into account the unobservable country heterogeneity effects, but incorporate these effects into the error terms, which are assumed to be uncorrelated with the explanatory variables. To choose the appropriate model for the panel data set from these two competing models, the Hausman test based on Hausman (1978) is performed. Additional diagnostic tests such as collinearity checks based on the variance inflation factor (VIF)<sup>5</sup> and groupwise heteroskedasticity test are carried out.<sup>6</sup>

### 5. Estimation Results and Discussion

Tables 1 and 2 present the correlation matrix for all included explanatory variables and the ICT variables and the results of collinearity checks for these variables. Correlation coefficients for all included explanatory variables are low, suggesting no harmful multicollinearity among these variables (Table 1). However, the correlation coefficients and the variance inflation factor (VIF) values for most of the ICT variables are relatively high, indicating that there is a high multicollinearity among the ICT variables (Table 2). These high inter-correlations affect the estimation results as they pose difficulty in identifying statistically the influence of a specific ICT factor on goods exports. To circumvent these high correlation problems, we include the ICT variables, namely fixed telephone subscriptions, mobile cellular subscriptions, fixed broadband subscriptions per 100 people, and Internet users as percentage of population, one by one in the estimations of specification (1). We carried out the Hausman test to choose between fixed-effects vs. random-effects models. The Hausman statistics are highly significant, providing evidence that there is correlation between the explanatory variables and the error terms. The fixed-effects technique, therefore, is statistically more appropriate.

However, the use of the fixed-effects method drops all time-constant variables. Therefore, Hausman and Taylor (HT) approach, which is based on Hausman and Taylor (1981), is employed. The HT approach does not only address the endogeneity issue, but it also provides the estimates for important time-invariant variables. The HT approach was used in a number of previous studies on international trade flows (McPherson and Trumbull, 2008; de Jong and Bogmans, 2011).

Table 1: Correlation Matrix for Included Explanatory Variables

Variable Name	1	2	3	4	5	6	7	8
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<sup>5</sup> The commonly-used rule of thumb states that if  $VIF < 5$ , there is no evidence of damaging multicollinearity (Studenmund, 2017).

<sup>6</sup> Since the panel data set used for the analysis is unbalanced with gaps, it is impossible to carry out the unit-root test. In addition, based on the previous work on Cambodia (Cuyvers et al., 2011; Soeng and Cuyvers, 2018), there is less concern about non-stationarity of the included time-variant variables.

1. LnFDI	1.00							
2. LnGNICAP	0.07	1.00						
3. LnPOP	0.21	-0.40	1.00					
4. LnEXCH	0.06	-0.55	0.27	1.00				
5. Trade Freedom	0.07	0.05	-0.01	0.03	1.00			
6. Border	0.20	-0.30	0.10	0.40	$4 \times 10^{-3}$	1.00		
7. GSP	-0.02	0.48	-0.02	-0.34	0.10	-0.14	1.00	
8. ASEAN	0.23	-0.19	$4 \times 10^{-3}$	0.22	0.04	0.60	-0.18	1.00

Notes: - *Ln* denotes values in natural logarithm.

- *FDI* is foreign direct investment; *POP* is population of trading partners; *GNICAP* is GNI per capita of trading partners; *EXCH* is ratio of Cambodian riels per US\$ exchange rate to the trading partner's national currency per US\$ exchange rate; *GSP* is generalized system of preferences; *Border* is binary variable; and *ASEAN* is dummy variable, which is equal to 1 for trading partners that are member of ASEAN.

Source: Author's calculation.

Table 2: Correlation Matrix and VIF values for ICT Variables

Variable Name	VIF	LnFP	LnMP	LnBB	LnInternet
LnFP	7.62	1.00			
LnMP	51.20	0.813	1.00		
LnBB	22.64	0.672	0.948	1.00	
LnInternet	4.51	0.769	0.939	0.805	1.00

Notes: *LnFP* refers to log of fixed telephone subscriptions per 100 people; *LnMB* is log of mobile cellular subscriptions per 100 people; *LnBB* is log of fixed broadband subscriptions per 100 people; and *LnInternet* refers log of individuals using the Internet as percentage of population.

Source: Author's calculation.

There may exist reverse causal relationship between exports and ICT variables (Freund and Weinold, 2004), which results in biased estimated coefficients of the ICT variables. Following Freund and Weinold (2004), estimation is carried out with the ICT variables lagged by two years to reduce the possible reverse causality issue as exports in current year are unlikely to affect the ICT variables years ago.

Table 3 shows the estimation results for the effect of broadband penetrations on Cambodia's goods exports over the period under investigation.<sup>7</sup> For the purpose of comparison, results from the RE and FE methods are also reported along with those of HT method. Yet, the interpretations are based on the empirical results of the HT approach. As expected, the coefficient on population, which is a proxy for market size for importing countries, is positive and highly significant at the 1% significance level. This finding is consistent with many previous studies and the gravity model hypothesis, which predicts that bilateral trade flows increase as market size becomes larger. Similarly, coefficient on GNI per capita, a proxy for purchasing power of

<sup>7</sup> With the suggestion of an autonomous referee, tariff rate was included as an additional explanatory variable in the estimation. However, it is highly insignificant, and thus is excluded.

importing countries, is statistically significant at the 1% level. The estimated coefficient of 0.97 suggests that a one percent increase in per-capita income of trading partners leads to an increase of 0.97% in their goods imports from Cambodia. This provides evidence that an increase in per-capita incomes of the importing countries translates into higher demand of the trading partners for imports from Cambodia.

Estimated coefficient on FDI is positive and significant at 10% level, which suggests that FDI is positively related to Cambodia’s goods exports. Based on Table 3, a one percent increase in inward FDI will lead to about 0.1% rise in the Kingdom’s exports of goods. Trade freedom is positive and highly significant at less than 1% level. This finding is in line with the Cambodian Government’s continued liberalization policy towards foreign direct investment and international trade with the outside world.

**Table 3: Estimation Results for Broadband Penetration**

Variable	RE	FE	HT
Constant	-24.947*** (3.540)	-43.745 (63.563)	-19.054*** (4.411)
LnBB <sub>t-2</sub>	0.103** (0.041)	0.186*** (0.060)	0.234*** (0.033)
LnFDI	0.109* (0.063)	0.072 (0.078)	0.098* (0.051)
LnGNICAP	1.112*** (0.170)	0.488 (0.407)	0.966*** (0.180)
LnPOP	1.015*** (0.086)	2.949 (3.836)	0.908*** (0.197)
LnEXCH	0.079 (0.053)	-0.592 (0.433)	-0.011 (0.143)
Trade Freedom	3.058*** (0.745)	2.306*** (0.836)	2.639*** (0.334)
Border	2.899** (1.127)	–	2.195 (2.050)
GSP	0.283 (0.274)	0.175 (0.262)	0.027 (0.232)
ASEAN	1.104 (0.693)	–	1.104 (1.213)
No. of Observations	477	477	520
Overall R <sup>2</sup>	0.7449	0.1927	
Hausman Test	FE vs. RE: 23.85***		

Notes: 1.Ln denotes values in natural logarithm.

2. \*, \*\*, and \*\*\* denote that the slope parameter estimates are statistically significant at less than the 10%, 5%, and 1% levels, respectively.

3. Standard errors are heteroskedasticity robust standard errors in parentheses.

4. FDI is foreign direct investment; POP is population of trading partners; GNICAP is GNI per capita of trading partners; EXCH is ratio of Cambodian riels per US\$ exchange rate to the trading partner’s national currency per US\$ exchange rate; GSP is generalized system of preferences; Border is binary variable; ASEAN is dummy variable, which is equal to 1 for trading partners that are member of ASEAN; BB is fixed broadband subscriptions per 100 people in Cambodia.

Source: Author’s estimation.

Interestingly, coefficient of the variable of interest, broadband which is a proxy for ICT, has the expected positive sign and significant at the 1% significance level, providing strong evidence that ICT is an important determinant of Cambodia’s goods export performance. The result suggests that better ICT infrastructure enhances Cambodia’s exports to its trading partners. Intuitively, trade flows are enhanced by having an access to ICT, which reduces trade cost, entry costs to foreign markets,

coordination costs associated with production process, interaction costs between exporting firms and customers, and information costs about prices of goods. Thus, ICT is an important ingredient for exporters and producers as well as firms to overcome traditional impediments associated with restricted access to information on potential markets for their goods. This result is consistent with Barbero and Rodriguez-Crespo (2018) who found a positive and significant effect of broadband on trade for a sample of 232 European regions in 2007 and 2010. This finding confirms the important role played by ICT in boosting exports of Cambodia to the outside world.

Table 4: Estimation Results for Internet Penetration

Variable	RE	FE	HT
Constant	-21.039*** (2.387)	46.085 (42.730)	12.223 (9.900)
LnInternet <sub>t-2</sub>	0.279*** (0.040)	0.385*** (0.039)	0.395*** (0.032)
LnFDI	0.097* (0.055)	0.050 (0.050)	0.067 (0.042)
LnGNICAP	1.050*** (0.205)	1.062** (0.395)	0.878*** (0.140)
LnPOP	1.020*** (0.099)	-2.971 (2.628)	-0.566 (0.581)
LnEXCH	0.172** (0.083)	0.311 (0.317)	0.089 (0.201)
Trade Freedom	2.055*** (0.441)	2.334*** (0.395)	1.012*** (0.323)
Border	3.083** (1.377)	-	6.495 (6.376)
GSP	0.003 (0.304)	-0.199 (0.324)	-0.075 (0.167)
ASEAN	1.077 (0.723)	-	-1.128*** (0.416)
No. of Observations	576	576	600
Overall R <sup>2</sup>	0.7289	0.0257	
Hausman Test	FE vs. RE: 27.50***		

Notes: 1.Ln denotes values in natural logarithm.

2. \*, \*\*, and \*\*\* denote that the slope parameter estimates are statistically significant at less than the 10%, 5%, and 1% levels, respectively.

3. Standard errors are heteroskedasticity robust standard errors in parentheses.

4. FDI is foreign direct investment; POP is population of trading partners; GNICAP is GNI per capita of trading partners; EXCH is ratio of Cambodian riels per US\$ exchange rate to the trading partner's national currency per US\$ exchange rate; GSP is generalized system of preferences; Border is binary variable; ASEAN is dummy variable, which is equal to 1 for trading partners that are member of ASEAN; Internet is individuals using the Internet as percentage of population in Cambodia.

Source: Author's calculation.

Table 4 reports the estimation results for the Internet use. Coefficient on Internet use is positive and highly significant at the 1% level, which shows a positive relationship between the Internet and Cambodia's exports of goods over the period under investigation. Controlling for other determinants of goods exports, the estimate of Internet penetration is 0.395, which is economically large. This suggests that a one percent point increase in the Internet use in Cambodia, *ceteris paribus*, leads to about 0.4 percent point increase in the country's goods exports to its trading partners. Other control variables, such as per-capita income and trade freedom, retain their statistical significance at the 1% level.

Table 5 reports the results of mobile phone subscriptions. As expected, coefficient on mobile phones is positive and statistically significant at the 1% level, indicating that mobile phone penetrations are significant determinant of goods exports of Cambodia. The estimate is about 0.42, which implies that a one percent point increase in mobile phone subscriptions is positively associated with 0.42 percent point increase in goods exports. With respect to fixed phone penetrations, the estimation results show that fixed phone subscriptions are highly significant (Table 6). Its estimated coefficient is about 0.16, implying that an increase of one percent point of fixed phone subscriptions leads to an increase of goods exports of about 0.16 percent point. It should be noted that the economic significance of fixed phone subscriptions is relatively smaller than that of the other proxies for ICT, namely broadband, Internet use and mobile phones. This is not surprising as fixed phone line subscriptions have been on a decreasing trend while the uses of the Internet and mobile phones increase over time (Figure 1).

Table 5: Estimation Results for Mobile Phone

Variable	RE	FE	HT
Constant	-23.270 (45.025)	-23.270 (45.025)	-7.981 (6.437)
LnMP <sub>t-2</sub>	0.427*** (0.065)	0.427*** (0.065)	0.422*** (0.045)
LnFDI	0.128* (0.069)	0.128* (0.069)	0.097** (0.044)
LnGNICAP	1.219** (0.456)	1.219** (0.456)	0.729*** (0.160)
LnPOP	1.259 (2.781)	1.259 (2.781)	0.489 (0.344)
LnEXCH	0.098 (0.343)	0.098 (0.343)	-0.324* (0.183)
Trade Freedom	1.432*** (0.417)	1.432*** (0.417)	2.278*** (0.305)
Border	—	—	2.526 (3.240)
GSP	0.238 (0.329)	0.238 (0.329)	-0.007 (0.175)
ASEAN	-0.696** (0.293)	-0.696** (0.293)	-0.982** (0.430)
No. of Observations	591	591	600
Overall R <sup>2</sup>	0.6553	0.0511	
Hausman Test	FE vs. RE: 58.76***		

Notes: 1.Ln denotes values in natural logarithm.

2.\*, \*\*, and \*\*\* denote that the slope parameter estimates are statistically significant at less than the 10%, 5%, and 1% levels, respectively.

3.Standard errors are heteroskedasticity robust standard errors in parentheses.

FDI is foreign direct investment; POP is population of trading partners; GNICAP is GNI per capita of trading partners; EXCH is ratio of Cambodian riels per US\$ exchange rate to the trading partner’s national currency per US\$ exchange rate; GSP is generalized system of preferences; Border is binary variable; ASEAN is dummy variable, which is equal to 1 for trading partners that are member of ASEAN; MP is mobile cellular subscriptions per 100 people in Cambodia.

Source: Author’s calculation.

Table 6: Estimation Results for Fixed Phone

Variable	RE	FE	HT
Constant	-18.741*** (2.957)	40.896 (47.055)	-28.499*** (7.225)
LnFP <sub>t-2</sub>	0.325*** (0.058)	0.505*** (0.082)	0.157*** (0.056)
LnFDI	0.106* (0.064)	0.030 (0.054)	0.193*** (0.045)
LnGNICAP	0.854*** (0.215)	0.628 (0.397)	1.537*** (0.145)
LnPOP	0.938*** (0.115)	-2.127 (2.807)	1.301*** (0.398)
LnEXCH	0.174** (0.080)	-0.370 (0.362)	-0.277 (0.207)
Trade Freedom	2.065*** (0.457)	1.796*** (0.385)	2.200*** (0.382)
Border	4.094*** (1.182)	-	2.859 (3.940)
GSP	0.038 (0.288)	-0.102 (0.290)	0.392** (0.181)
ASEAN	-0.354 (0.287)	-0.920*** (0.279)	-0.531 (0.457)
No. of Observations	591	591	600
Overall R <sup>2</sup>	0.7132	0.5004	
Hausman Test	FE vs. RE: 20.14***		

Notes: 1.Ln denotes values in natural logarithm.

2.\*, \*\*, and \*\*\* denote that the slope parameter estimates are statistically significant at less than the 10%, 5%, and 1% levels, respectively.

3.Standard errors are heteroskedasticity robust standard errors in parentheses.

4.FDI is foreign direct investment; POP is population of trading partners; GNICAP is GNI per capita of trading partners; EXCH is ratio of Cambodian riels per US\$ exchange rate to the trading partner's national currency per US\$ exchange rate; GSP is generalized system of preferences; Border is binary variable; ASEAN is dummy variable, which is equal to 1 for trading partners that are member of ASEAN; FP is fixed telephone subscriptions per 100 people in Cambodia.

Source: Author's calculation.

## 6. Concluding Remarks

The present paper started with stock taking of the development of ICT, which is an important infrastructure to promote trade, as well as to transform Cambodia's narrow-based economy into a knowledge-based or digital one. Although ICT in Cambodia is currently at the infancy stage, it has developed rapidly and been introduced into many sectors of the Cambodian economy including public sector, education, tourism, health, transport, administration, and commercial activities. To support the ICT sector and ICT applications, the Royal Government of Cambodia has made great efforts to build both ICT infrastructure and ICT-related legal frameworks to promote ICT investments, provide protection for consumers, data and privacy, and bolster users' confidence in adopting and using the innovative technology system. Concurrently, access to information has been streamlined through government policy to promote the ICT sector and fair competition in the sector. Investment in telecommunications has been particularly encouraged.

The effects of ICT on Cambodia's goods export were investigated empirically, using the augmented gravity model with a panel data set from 84 trading partners between 1996 and 2017. We controlled the widely-used gravity masses, such as population, income per capita, FDI, exchange rate, trade freedom, and a set of binary

variables, which are believed to affect Cambodia's exports to its trading partners. Several diagnostic tests were carried out to choose the best estimation model. Additional tests were also undertaken including multicollinearity checks based on the variance inflation factor (VIF), and group-wide heteroskedasticity test to avoid presenting spurious estimation results.

The estimation results provide strong support to the roles of ICT in promoting Cambodia's goods exports. Since ICT is found to be an important and significant determinant of Cambodia's exports, further development of the country's ICT infrastructure is particularly encouraged. The need to overcome infrastructural bottlenecks in the telecommunications and transport system should be effectively addressed in order to promote trade flows both nationally and internationally. Improvements should be made in a number of areas including streamline efficient import and export procedures; upgrading of the ICT infrastructure with tax incentives made available for private sector's participations and investment in ICT and related sectors. As indicated by Xing (2018), access to technology and ICT combined with relevant skills and capacities to use these new technologies is critically vital. Thus, ICT education and capability training in ICT and new technologies are necessary to enable citizens to make productive uses of these technologies. While Cambodia has an abundant young low-cost labor force, there remain challenges of developing IT literacy and education to ensure the quality and size of the IT workforce to develop the country's digital economy.

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**APENDIX A: Cambodia's Trading Partners in the Sample**

Algeria	Costa Rica	Israel	Norway
Argentina	Cote d'Ivoire	Italy	Pakistan
Australia	Croatia	Japan	Peru
Austria	Cyprus	Kazakhstan	Philippines
Bahrain	Czech Republic	South Korea	Poland
Belarus	Denmark	Kuwait	Portugal
Belgium	Dominican Republic	Lao PDR	Qatar
Brazil	Egypt	Latvia	Romania
Brunei Darussalam	El Salvador	Lebanon	Russian Federation
Bulgaria	Estonia	Lithuania	Saudi Arabia
Canada	Finland	Luxembourg	Serbia
Chile	France	Macao	Singapore
China	Germany	Malaysia	Slovak Republic
Colombia	Greece	Malta	Slovenia
Congo	Hong Kong	Mauritius	South Africa
Turkey	Hungary	Mexico	Spain
Ukraine	Iceland	Moldova	Sri Lanka
Uruguay	India	Morocco	Sweden
United States	Indonesia	Netherlands	Switzerland
Vietnam	Ireland	New Zealand	Thailand
United Arab Emirates	United Kingdom	North Korea	Taiwan