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Digitizing Malaysia: Examining the Role of ICT in Malaysia's Exports of Goods and Services

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Abstract

ICT plays an important role in Malaysia's aims to develop a digital economy. Given the importance of trade in Malaysia, the objective of this study is to examine the impact of ICT on goods and services exports. Unlike previous models, the study constructs an ICT development index to test for the impact of ICT. It also differs from previous studies in using ICT network to capture network effects on international trade. A gravity model is used on a set of panel data from 2000 to 2012. The findings indicate that while ICT development increases services export, the impact of ICT network is not significant for goods export. Trade costs, however, have a significant impact on both services and good exports. Therefore, policies to promote goods and services exports in Malaysia have to consider improving connectivity together with the development of ICT in the country and the region.

Keywords: Gravity model, ICT, International Trade, Malaysia, Services exports

JEL Classifications: F14, F15, O14

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1. Introduction

The advent of the fourth industrial revolution has increased the pace of digitization in the world and with it, the use of Information, Communication and Technologies (ICT). Malaysia has promoted the use of ICT since the launch of the Multimedia Super Corridor (MSC) in 1996. Malaysia subsequently launched a Digital Malaysia (DM) program in 2012, in a bid to reposition the country in the world's changing digital economy and the rapid changes in technologies since the MSC (Digital News Asia, 2012). The important role played by ICT in developing DM was recognised with Malaysia targeting an increase in the contribution of ICT to the Gross Domestic Product (GDP) from 9.8 percent in 2010 to 17 percent by 2020. The most recent data from the Department of Statistics in Malaysia indicates that the target has already been achieved as the contribution of ICT to the country's GDP in 2016 amounted to 18.2 percent (Department of Statistics, 2017).

ICT contributes towards development as a production sector as well as an enabler of socio-economic development (UNDP, 2001). In the case of the latter, the development enabling functions of ICT have generally focused on issues such as health, education and environment (UNCTAD, 2011). However, ICT's impact on international trade is increasingly becoming a part of the latter discourse, be it in terms of ICT-related trade or the trade facilitating functions of ICT (Stoler, 2003; UNESCAP 2010), as international trade is deemed to contribute towards the growth and development of a country. Given that Malaysia is a trading nation, with international trade accounting for 136 percent of GDP in 2017, ICT is also harnessed to facilitate trade, especially exports. Since trade flows decrease with increasing distance, overcoming distance as a trade barrier becomes a crucial but costly concern, as suggested by the transaction cost theory. With the advancement of technology, studies have shown that ICT affects a country's international trade by overcoming distance-related trade costs (Abeliansky & Hilbert, 2014; Lennon, 2009; Mattes et al., 2012).

The focus of this study is to examine the role of ICT as a general facilitator of goods and services exports in Malaysia. While past research has shown the channels whereby ICT can be used to increase exports (by reducing trade costs), by using Malaysia as the country of analysis, this study also attempts to address the sparse literature of ICT-international trade nexus for developing countries. Specifically, this paper examines the impact of ICT on Malaysia's exports, using two separate gravity models of trade flows from 2000 to 2012, one of which is for goods while the other is for services.

This paper is structured as follows. In Section 2 the literature is reviewed while the methodology and data are presented in Section 3. A discussion of the results is provided in Section 4, followed by some policy suggestions in the conclusion in Section 5, which also summarizes the key findings of this paper.

2. Literature Review

There are two strands of literature that undergird this study. The first strand examines the contribution of international trade to growth and development while the second investigates the impact of ICT on trade. In the case of the former, while traditional trade theories such as the Heckscher-Ohlin-Samuelson (HOS) model of trade~~,~~ show that international trade leads to potentially better welfare conditions compared to autarky, endogenous growth models yield a positive trade-growth nexus only under certain conditions. For example, trade fosters growth if an economy ends up specialising in

activities that generate long-run growth based on comparative advantage. The empirical evidence is inconclusive due to the use of different proxies and methods (Keho and Wang, 2017).

The literature review covers only the impact of ICT on trade or exports in goods and services as it pertains to the research question of this paper. ICT affects exports through direct and indirect impact. ICT directly impacts a firm's backward and forward linkages by digitally linking its suppliers, distributors and retailers in a seamless process. This is because ICT-supported intermediation between sellers and buyers creates an e-marketplace that reduces the cost for acquiring information about seller prices and product offerings, thereby reducing market inefficiencies (Abelinsky & Hilbert, 2014). The Internet also reduces other transaction costs such as local distribution and logistics costs, and advertising costs (Timmis, 2012). Timmis further noted that production fragmentation across borders is also facilitated with the use of the Internet for coordinating different production tasks. ICT deployment also brings about organizational changes and digitalization, leading to a reduction in shipping costs (Yushkova, 2014). Transit time and its related transport costs can also be reduced by using ICT (Ahmad et al., 2011; Lennon 2009; Mattes et al., 2012; Yushkova, 2014). It is, however, important to note that these costs can only be reduced if the penetration of ICT is high enough.

The use of ICT also indirectly improves firms' productivity. Efforts such as digitization and automation enables the production processes within the firm to become more efficient and thus reduces costs affiliated to production errors. A high level of ICT adoption among exporters also indirectly improves the industry through market competition. Industries with strong automation and digitalization technology are able to capture higher value in the production network. This may further attract higher quality investments and create exports with higher technology content (UNCTAD, 2019).

Many studies have adapted Tinbergen's (1962) gravity model in empirical studies on trade (Grünfeld & Moxnes, 2003; Kimura & Lee, 2006). The gravity model (which will be further explained in the methodology section) is used as an instrument to test whether a reduction in trade costs, with the use of technology and innovation (or ICT), leads to an increase in international trade in services (Freund & Weinhold, 2004; Goswami et al., 2011; Lee, 2012; Dettmer, 2014) or in both trade in goods and services (Lennon, 2009; Lennon et al., 2009). These studies, however, are done mostly in developed countries, leaving a literature gap for developing countries. Freund and Weinhold (2002) showed in their gravity model that the Internet enhances services trade flows by reducing the need for physical contact between producers and consumers. Kimura and Lee (2006) also applied the gravity framework to services trade and found that the distance between countries has a greater impact on services trade in comparison to goods trade, suggesting possibly higher transport costs in services trade. However, they did not provide any reason as to why this may be the case. In general, these studies find that ICT has a positive impact on trade, and the impact is greater in services trades compared to goods trades. This is particularly so when ICT enables previously non-tradable services to become tradable, due to the characteristics of some services such as e-banking and e-commerce.

However, econometric studies are constrained by data limitations in ascertaining the impact of ICT for developing countries (United Nations, 2011), especially for its impact on services trade. Usually, studies from developed countries are often supported by sufficient data sets which focus on macro (Freund & Weinhold, 2004; Mattes et al., 2012; Van der Marel, 2012) and micro analysis (Kotnik & Hagsten, 2013; Sinkovics & Sinkovics, 2013). Due to the lack of available macro data, much of the evidence from developing countries is supported only by local case studies (Ahmad et al., 2011; Bankole et al., 2010). Even then, the case studies in developing countries are also sparse due to data problems. Therefore, more developing country studies are needed in order to

understand the role of ICT in facilitating international trade. This study therefore adds value to the literature on developing countries by estimating a gravity model for the case of Malaysia, which is also a relevant case study due to its policy aspirations as explained in the introduction.

In the case of Malaysia, Ahmad et al. (2011) examined the impact of ICT infrastructure on goods trade by using a gravity model and a number of indicators for ICT infrastructure. Based on a set of panel data of 36 trading partner countries from 1980 to 2008, it was found that mobile and fixed-line telephone subscribers, personal computers and internet users are significant variables and they are positively related to the value of one way goods trade between Malaysia and its trading partners. However, Ahmad et al. (2011) neglected the network effect, which was stressed in services trade by Mattes et al. (2012). The literature indicates there are potential avenues for ICT network effects (Choi, 2010; Mattes et al., 2012).

The novel contribution of this study is to embed the two types of network effects into the analysis: (i) Direct network effects, whereby the value of a service increases with an increase in the number of users, and (ii) indirect network effects, where an increase in consumer use leads to an increase in the number of higher quality producers (Katz & Shapiro, 1985; Weitzel et al., 2003). This study adds value to the literature by capturing the characteristics of networks suggested by Farahani & Parvardeb (2012) and hypothesise that ICT can only enhance trade when both trading partners have a similar and good level of ICT development. Empirical studies also show that transnational networks encourage international trade by providing information on opportunities in trade networks, thus reducing the cost of trade (Albuquerque et al., 2005; Greaney, 2005; 2009; Rauch, 2001; Swenson, 2004; Lee, 2012). These business network effects operate on the same principles as ICT network effects.

Lee (2012) examined the role of the network effects of FDI, migration, and the Internet on international trade for 23 OECD countries. His study showed that there are differences in the network effect for the manufacturing and service sectors. The Internet is the most important channel for the network effect for both sectors. But migration is important only for the manufacturing sector. However, the results of Lennon (2009) supported the argument that technological advances are more influential on services trade, most probably because they have allowed initially non-tradable services to become tradable.

Overall, the literature has yet to show conclusively that the impact of ICT on goods is different or the same as the impact of ICT on services exports as this depends on the characteristics of services trade of the countries studied. To summarize, there is a gap in understanding the impact of ICT on exports in a network context as studies on the impact of ICT networks on international trade are relatively sparse. The lack of data contributed to this gap. The introduction of the ICT development index (IDI) has opened up opportunities for a study on the impact of ICT networks on international trade.

The ICT development index (IDI) seeks to monitor the development of ICT across countries (ITU 2009). This index greatly expands the measurement of ICT beyond mere Internet use alone and allows for a deeper analysis on the impact of ICT on trade. This study further contributes to the literature by constructing a time variant ICT index (IDI) to test the impact of ICT on the Malaysia's services exports compared to the exports of goods.

While firms engaging in services exports improved from 19.7 percent in 2006 to 30.5 percent in 2014 (Munoz Moreno et al. 2016; The World Bank 2009), Malaysia's total exports of services has experienced a decline compared to exports of goods (10th Malaysia Plan, 2010). Therefore, the role of ICT in firms' exports has yet to be explored

in depth, particularly in the case of Malaysia. This study therefore adds value by comparing the impact of ICT on exports of goods and services in Malaysia to other countries.

3. Model

A gravity model is used to evaluate the impact of ICT on services and good exports as it is widely utilized in the empirical literature to explain the main links between trade barriers and trade flows. The basic model for trade between two countries (*i* and *j*) takes the form of:

$$F_{ij} = G\frac{Y_i Y_j}{D_{ij}} \quad (1)$$

Where the value of country *i* exports to country *j* denotes by F_{ij}; $Y_i Y_j$ is the proxy for market size (or gross domestic product (GDP)) of both country *i* and country *j*; D_{ij} captures trade and transportation costs as indicated by the distance between country *i* and country *j* and *G* is a constant.

Estimation of the standard gravity model of equation (1) in the logarithmic form is stated as follows:

$$ln(F_{ij}) = \delta_0 + \delta_1 lnY_i + \delta_2 lnY_j - \delta_3 lnD_{ij} + \sigma \quad (2)$$

Generally, potential obstacles and trade determinants are tested by gravity models in international trade studies (Helpman et al., 2008). However, the gravity model is used more extensively for trade in goods compared to trade in services, possibly due the lack of services export data by country especially in developing countries where the available data is usually the overall export of services to the world. Nevertheless, Grünfeld & Moxnes (2003) and Kimura & Lee (2006) have successfully implemented the gravity model in services trade. Walsh (2011) also supported the use of the gravity model for examining trade in services because his findings suggested that the gravity model fits services trade flows in a similar manner as in trade in goods. Hence this model can be applied for both trade in goods as well as services.

Additional "non-physical distance" (for example, cultural "distance" inter alia proxy by language barriers, colonial history, etc.) are also commonly used to explain transaction costs that affect trade in the gravity model as an extension of studies on physical distance. The language variable will be used in this study. When we assume that trading partners use the same language, information loss or friction is low, thereby reducing search costs in trade (Lendle et al., 2016).

In this model, there are two advantages favoring the use of network effects for ICT and business. First, it shows the impact of the networks, which is shown to be important in the literature. Second, it reduces the endogeneity problem in FDI and ICT with trade as it avoids the direct impact of FDI and ICT on trade.

Adapting from Mattes et al. (2012), our ICT variable will be defined as ICT development (ICT) in the gravity equation. The variable is created to further examine the role of ICT on economic development through trade. It takes into account the ICT development of both the importer and exporter to enable us to test the hypothesis that ICT enhances trade only when both countries have high level of ICT development. The variable is constructed as follows:

$$\mathrm{ICT}_{ij} = \mathrm{ICT}_i \; x \; \mathrm{ICT}_j \qquad (3)$$

Where ICT_{ij} is the selected ICT indicator for country *i* and country *j*. It is an interaction term that measures ICT development of both countries.

Since the literature review also points to the importance of accounting for transnational networks of ICT, we use a new variable to control the impact of business network in international trade between two countries. We apply the method by Lee (2012) that uses FDI flows as a proxy for the effects of business development networks. The specification is constructed as follows:

$$\mathrm{FDI}_{ij} = \mathrm{FDI}_i \; x \; \mathrm{FDI}_j \qquad (4)$$

FDI_{ij} is constructed as an interaction term between FDIs in country *i* and country *j*. Equations (3) and (4) capture the "network effect" for ICT and FDI respectively on trade in goods and services Hence, the final model specification for the augmented gravity model is as follows:

$$\ln(\mathrm{X}_{ijt}) = \beta_0 + \beta_1 \ln\mathrm{GDP}_{ijt} + \beta_2 \ln\mathrm{Dist}_{ij} + \beta_3 \mathrm{LG}_{ij} + \beta_4 \ln\mathrm{FDI}_{ijt-1} + \beta_5 \ln\mathrm{ICT}_{ijt-1} + \varepsilon \qquad (5)$$

Where	X	Exports (US$). Equation (5) will be estimated separately for (i) Goods and; (ii) Services exports
	GDP	GDP (constant 2005 US$)
	Dist	Geographical distance - latitudes and longitudes of the most important cities/agglomerations base on population
	LG	Common spoken language - Common spoken language – dummy variable (0 or 1) that a pair of people at random from the two countries uses the same language.
	FDI	Foreign direct investment, net inflows (current US$), from (4)
	ICT	ICT development indicators, from (3).
	i	Malaysia
	j	Imports country
	t	Years (2000-2012)

Where X refers to one way goods and service export. $\ln\mathrm{GDP}_{ij}$ is the log of the product of real GDP of both country *i* and country *j*. It is hypothesized that GDP will affect goods and services exports positively, or that the larger the economic mass of partner countries is, the larger the export of goods and services to these countries as demand from importing countries becomes larger. $\ln\mathrm{Dist}_{ij}$ refers to the log of distance between countries *i* and *j* which proxies trade costs between them. Distance, however, is hypothesized to affect goods and services exports negatively since longer distances imply larger trade costs and hence reduces exports of services and good. LG_{ij} refers to Common spoken language – dummy variable (0 or 1) that a pair of people at random from the two countries uses the same language. $\ln\mathrm{FDI}_{ij}$ and $\ln\mathrm{ICT}_{ij}$ are the network effects explained in equations 3 and 4. FDI is expected to influence goods and services exports positively since increases in FDI enhance the capacity of host economies to export through spill overs. Similarly, ICT is also expected to influence goods and services exports positively, as explained earlier. Following Baccini & Urpelainen (2014), lagged values of FDI and ICT are used to further remove possible endogeneity issues between FDI and exports,

and ICT development and exports. Note that the models are estimated with cluster-robust standard errors to remove the presence of heteroskedasticity.

4. Data and estimation

The paper covers 41 one-way trade partners[1] of Malaysia from 2000 to 2012.[2] The services trade data is obtained from the Trade Map (International Trade Centre) for service data (also known as mirror data) and good data were obtained from UN Comtrade. Data on FDI, GDP and school enrolment-secondary and tertiary data were taken from the World Development Indicators (The World Bank 2017). The physical distance data were from CEPII (Centre D'Etudes Prospectives et D'Informations Internationales) (Mayer & Zignago 2011), common spoken language data were from Central Intelligence Agency (CIA) World Factbook (CIA 2017), and the ICT indicator data were generated from the World Telecommunication/ICT Indicators database (ITU 2012). For further details, please refer to Table 1 below. The equation uses panel data estimation for both the goods and services equation.

Table 1: Variable description and sources

Variable	Definition	Source
One-way service export (mirror data)	Trade in services data on Trade Map refers to transactions between residents and non-residents of the compiling economy, as recorded within the Balance of Payment (BoP). One-way service export for Malaysia countries is mirror import from the trading partners.	ITC Trade Map
One-way service export (Robust test)	Gross exports (EXGR) data come from the row sum of the international trade flows in the Organisation for Economic Co-operation and Development (OECD) Inter-Country Input-Output (ICIO) tables. They are consistent with official (SNA93) National Accounts estimates of total exports and imports of goods and services, adjusted for re-exports, as well as estimates for GDP. However, while National Accounts	TiVA database, OECD

[1] The partner countries are key services trade partners of Malaysia and are selected based on the availability of services trade data from the ITC Trade Map database. They are Australia, Austria, Azerbaijan, Netherlands, Belarus, Belgium, Bulgaria, China, Croatia, Cyprus, Czech, Republic, Denmark, Estonia, Finland, Greece, Hong Kong, China, Hungary, Iceland, Ireland, Italy, Japan, Germany, Canada, Korea, Republic, Latvia, Lithuania, Luxembourg, Malta, Pakistan, France, Russian Federation, Poland, Romania, Spain, Singapore, Slovakia, Slovenia, Sweden, Tunisia, United Kingdom, and the United States.

[2] There are a few limitations in extending the data. First, there are changes in how some of the indicators are being defined in 2013 (*see* https://www.itu.int/en/ITU-D/Statistics/Documents/events/brazil2013/Final_report_EGH.pdf (accessed 4 July 2021)) hence making data extensions post 2012 is complicated due to the differences in variables' definitions. There are considerations on using post 2013 data. However, there was a change in the methodology and classifications of the balance of payments by the IMF in 2014 (from BPM5 to BPM6). This further affects the interpretation in services trade data. Therefore, the longest uninterrupted time series data before 2013 are from 2000 to 2012. In addition to this, using data from 2000 to 2012 has its merits for Malaysia in terms of the analysis of the paper. In 2000, the Eighth Malaysian Plan (8MP) (2001 – 2005) was introduced. It was the first Malaysian plan after the National IT Agenda was formulated (in 1996). The Agenda provided the framework for the orderly development of the country into an information and knowledge-based society by 2020 (8th MP). The 8MP was also the first economic plan with a designated Chapter that uses the term "Information and Communications Technology" (Chapter 13) – previously in the 7th MP, only "Information Technology". One can argue that the 8th MP inaugurated the government's main focus towards an ICT-driven economy. The data used in this study therefore fits the phase where Malaysia shifted its key focus on ICT. During the review period, substantial efforts were also undertaken to "…*foster the local ICT industry to export indigenously developed technology through the technopreneur development flagship…* - 8th Mid-Term Review of the Eighth Malaysia Plan, Pg. 289".

Variable	Definition	Source
	exports are valued at purchaser's prices, Gross exports for Trade in Value Added (TiVA) indicators are valued at basic prices in line with the valuation used throughout the ICIO tables. When transforming exports from purchaser's prices to basic prices, one of the main adjustments is the reallocation of the domestic distribution margins, (inherent in exports of goods at purchaser's prices) to exports of services (wholesale, retail and transportation). A consequence is that, for many countries, total exports of services in the TiVA database may be significantly higher than total exports of services reported in National Accounts (and Balance of Payments) statistics.	
GDP (constant 2005 US$)	GDP at purchaser's prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in constant 2005 U.S. dollars. Dollar figures for GDP are converted from domestic currencies using 2000 official exchange rates. For a few countries where the official exchange rate does not reflect the rate effectively applied to actual foreign exchange transactions, an alternative conversion factor is used.	The World Bank's World Development Indicators database
Geodesic distances	Geodesic distances are calculated following the great circle formula, which uses latitudes and longitudes of the most important cities/agglomerations (in terms of population)	CEPII dataset (geo_cepii)
Common spoken language	Dummy variable of 0 or 1 that a pair of people at random from the two countries understands one another in some language (into the ranking CIA).	CIA world factbook
Foreign direct investment, net inflows (BoP, current US$)	Foreign direct investment are the net inflows of investment to acquire a lasting management interest (10 % or more of voting stock) in an enterprise operating in an economy other than that of the investor. It is the sum of equity capital, reinvestment of earnings, other long-term capital, and short-term capital as shown in the balance of payments. This series shows net inflows (new investment inflows less disinvestment) in the reporting economy from foreign investors. Data are in current U.S. dollars. This series shows net inflows in the reporting economy and it is lagged by 1 year.	The World Bank's World Development Indicators database
Fixed-telephone subscriptions per 100 inhabitants	*Fixed-telephone subscriptions* refers to the sum of active analogue fixed-telephone lines, voice-over-IP (VoIP) subscriptions, fixed wireless local loop (WLL) subscriptions, ISDN voice-channel equivalents and fixed public payphones. It includes all accesses over fixed infrastructure supporting voice telephony using copper wire, voice services using Internet Protocol (IP) delivered over fixed (wired)-broadband infrastructure (e.g. DSL, fibre optic), and voice services provided over coaxial-cable television networks (cable modem). It also includes fixed wireless local loop (WLL) connections, which are defined as services provided by licensed fixed-line telephone operators that provide last-mile access to the subscriber using radio technology, when the call is then routed over a fixed-line telephone network (and not a mobile-cellular network).	ITU

Variable	Definition	Source
Mobile-cellular telephone subscriptions per 100 inhabitants	*Mobile-cellular telephone subscriptions* refers to the number of subscriptions to a public mobile-telephone service which provides access to the public switched telephone network (PSTN) using cellular technology. It includes both the number of post-paid subscriptions and the number of active prepaid accounts (i.e. that have been active during the past three months). It includes all mobile-cellular subscriptions that offer voice communications. It excludes subscriptions via data cards or USB modems, subscriptions to public mobile data services, private trunked mobile radio, telepoint, radio paging and telemetry services.	ITU
International Internet bandwidth (bit/s) per Internet user	International Internet bandwidth refers to the total used capacity of international Internet bandwidth, in megabits per second (Mbit/s). It is measured as the sum of used capacity of all Internet exchanges offering international bandwidth. If capacity is asymmetric, then the incoming capacity is used. International Internet bandwidth (bit/s) per Internet user is calculated by converting to bits per second and dividing by the total number of Internet users.	ITU
%age of individuals using the Internet	Individuals using the Internet refers to people who used the Internet from any location and for any purpose, irrespective of the device and network used. It can be via a computer (i.e. desktop computer, laptop computer or tablet or similar handheld computer), a mobile phone, a games machine, a digital TV, etc.). Access can be via a fixed or a mobile network.	ITU
Fixed (wired)-broadband subscriptions per 100 inhabitants	*Fixed (wired)-broadband subscriptions* refers to the number of subscriptions for high-speed access to the public Internet (a TCP/IP connection). High-speed access is defined as downstream speeds equal to, or greater than, 256 kilobit per second (kbit/s). Fixed (wired) broadband includes cable modem, DSL, fibre and other fixed (wired)-broadband technologies (such as Ethernet LAN, and broadband-over-power line (BPL) communications). Subscriptions with access to data communications (including the Internet) via mobile-cellular networks are excluded.	ITU
School enrolment, secondary (% gross)	Gross enrolment ratio is the ratio of total enrolment, regardless of age, to the population of the age group that officially corresponds to the level of education shown. Secondary education completes the provision of basic education that began at the primary level, and aims at laying the foundations for lifelong learning and human development, by offering more subject- or skill-oriented instruction using more specialized teachers.	ITU
School enrolment, tertiary (% gross)	Gross enrolment ratio is the ratio of total enrolment, regardless of age, to the population of the age group that officially corresponds to the level of education shown. Tertiary education, whether or not to an advanced research qualification, normally requires, as a minimum condition of admission, the successful completion of education at the secondary level.	ITU

Source: ITC (2017), OECD (2017), The World Bank (2017), Mayer & Zignago (2011), CIA (2017), ITU (2012)

4.1 Data on ICT development

The ICT Development Index (IDI) developed by the ITU in 2009, is a comprehensive index, aggregating 11 indicators into one index that is used to benchmark and monitor developments in information and communication technology (ICT) across countries. The IDI aims to track the digital divide and to measure countries' progress towards becoming information societies. It also gives an indication of the extent to which countries have advanced in the area of ICT development. ITU (2009) proposes a combination of a set of sub-indexes to measure three ICT components, namely ICT access, ICT use and ICT skills. These three ICT components are then aggregated to obtain the overall ICT indicator, or the IDI, which is explained below.

A country's ICT development can be explained in three stages:

1. Stage 1: ICT Access reflecting the level of networked infrastructure and access to ICTs;
2. Stage 2: ICT Intensity reflecting the level of use of ICTs in the society;
3. Stage 3: ICT impact reflecting the result/outcome of efficient and effective ICT use.
4. Moving through these stages depends on a combination of three components: (1) the availability of ICT infrastructure and access; (2) a high level of ICT usage; and (3) the capability to use ICT effectively.

To capture all three components, the construction of a composite index such as the IDI is required. ITU (2009) suggests that the construction of the IDI to be further divided into three sub-indices. The following are the only ones that are used for this study, based on the availability of data:

1. The "access" sub-index which captures ICT access and includes infrastructure and access indicators. ICT access is measured by fixed-telephone subscriptions per 100 inhabitants, mobile-cellular subscriptions per 100 inhabitants and international Internet.
2. The "use" sub-index which captures ICT intensity and includes ICT intensity and usage indicators. ICT use is measured by percentage of individuals using the Internet and fixed (wired) broadband Internet subscriptions per 100 inhabitants.

3. The "skills" sub-index which captures ICT capability or skills as indispensable input indicators. ICT skills are approximated by secondary gross enrolment ratio and tertiary gross enrolment ratio.

As the ITU indicator is not available for the full period of this study (2000-2012), the construction of the index is replicated based on the underlying data for which information over the relevant time period is available.[3] Additionally, since many countries already have high literacy rates, the literature suggests that this element can be omitted from the present study (Nath & Liu, 2016; Mattes et al., 2012).

All sub-indices (ICT access, ICT use, ICT skills) are computed by summing the weighted values of each item in its group. Based on Table 2, the items are normalized using the reference values in Table 3. Subsequently, the overall value of each sub-indices

[3] There are four elements that will be removed in the study. These are: households with a computer, households with internet access at home, mobile broadband subscribers per 100 inhabitants and adult literacy rate. The data for the first three indicators are not available for the required time period and countries and thus are omitted from the present study.

(ICT access, ICT use, ICT skills) is calculated by taking the simple average of the items. Finally, to aggregate the ICT sub-indices into one index, we use the weighting system generated from the Principal Component Analysis (PCA) method) from ITU (2009). ICT access and ICT use are each given a 40 percent weightage while the ICT skills sub-index weightage is set at 20 percent. The construction of our ICT indicator follows this method as it is also applied by ITU (2009). In addition, our indicator is interpreted in terms of network effect as explained in Equation 3.

Table 2: Construction of the ICT index (using the IDI method by ITU)

Sub-Indices (A),(B) and (C)	**Formula Normalized (x)**	**Weight**
ICT access (A)		
Fixed telephone lines per 100 inhabitants (a_t)	$a_t/60$	x*0.33
Mobile cellular telephone subscriptions per 100 inhabitants (b_t)	b_t/R_t	x*0.33
International Internet bandwidth (bit/s) per Internet user (c_t)*	$\log(c_t)/R_t$	x*0.33
ICT use (B)		
Internet users per 100 inhabitants (d_t)	$d_t/100$	x*0.5
Fixed broadband Internet subscribers per 100 inhabitants (e_t)	$e_t/60$	x*0.5
ICT skills (C)		
Secondary gross enrolment ratio (f_t)	$f_t/100$	x/2
Tertiary gross enrolment ratio (g_t)	$g_t/100$	x/2
Aggregated Index (IDI): (A)*0.4 + (B)*0.4 + (C) *0.2		

R = reference value, refer to Table 4, t = year,
*To remove large number of outliers at the high end of the value scale, the data were first transformed to a logarithmic (log) scale.
Source: ITU 2009.

Table 3: The reference value obtained through statistical procedures

Reference value	**b**	**c**
2000	93.50	4.10
2001	107.80	4.55
2002	116.75	4.63
2003	124.00	4.74
2004	129.09	4.83
2005	137.95	4.78
2006	149.71	5.09
2007	158.31	5.21
2008	161.17	5.38
2009	164.18	5.51
2010	167.50	5.63
2011	175.30	5.77

Notes: the reference value: mean + 2 * standard deviation
Source: Computed by authors, based on the method explained in ITU (2009).

5. Results and Discussion

The results for the panel data models for goods and services are shown in Table 4. The Hausman test suggests that the goods model uses the fixed-effect (FE) estimator while the services model uses the random-effect estimator (RE). Variables from the standard gravity model show the expected signs as shown in Table 4.

Table 4: Estimation results (dependent variable: One-way goods and service export)

Variables	(i) Goods	(ii) Services
GDP	0.98	1.23
	(0.04)***	(0.16)***
Distance	-1.58	-1.81
	(0.16)***	(0.48)***
Language	0.03	0.77
	(0.11)	(0.50)
FDI	0.09	0.05
	(0.02)***	(0.03)
ICT	0.01	0.83
	(0.11)	(0.33)***
Obs	343	254
R-sq: overall	0.93	0.72
Hausman	FE	RE#
# LM-Test (chi-bar^2)	-	310.55**
Correlation Max	0.60	0.50

Note: *** p<0.01, ** p<0.05, * p<0.1

A significant Breusch-Pagan Lagrange Multiplier test recommends the use of model RE

Although both coefficients for the network effect for the ICT indicator are positive, it is significant only for the services exports. The finding on the services sector is generally consistent with previous research whereby the impact of ICT is greater in services trades compared to goods trades. (Freund & Weinhold, 2002, 2004; Greaney, 2005, 2009; Lee, 2012; Mattes et al., 2012; Yinghua Meng, 2008). The insignificant coefficient for goods exports may be due to the inability of the IDI method to capture more sophisticated technology required for the production of goods. While ICT access, use and skills are important, the utilization of ICT for the production of goods exports may have transcended these general requirements.

For the services model, Table 4 shows that the coefficient of the ICT variable is significant as compared to the coefficient of the FDI variable (which is insignificant). This result suggests that the expansion of ICT network between countries facilitate more services export compared to the expansion of business network. One caveat is that the positive impact of ICT on trade in services may be offset by the presence of trade costs which affects services exports negatively. For the goods model, business networks are more important mainly because Malaysia is a country that is highly integrated in the global value chains through FDI. This may also explain why business network is significant in the goods equation in Table 4, but not for services, which is in general dominated by government-related companies (GLCs) in Malaysia. This is an important contribution to the study as it highlights the different impact of ICT on trade in goods and services.

One-way goods and services export increases with GDP implying that the larger the economic space, the larger the trade potential between two partners. Compared to goods exports, the results also suggest that coefficient for market size (GDP variable) for services is larger than goods. A possible explanation may lie in the nature of services, which is non-storable, hence making services export more sensitive towards ~~by~~ market demand relative to goods.

Geographical distance is important for both services and goods export, at a significance level of one percent. This is another important finding because for goods, the inverse relation between trade and distance is consistent with the gravity model. However, the importance of geographical proximity in the case of services warrants further clarification. Although services do not have to be physically transported from location to location, the result suggests that there are cases when it will require the

movement of physical persons such as in the movement of consumers and professional workers across borders. Depending on the nature of the services, trading activities may also be transmitted electronically. Therefore, the importance of distance in services trade may be low or even insignificant (Walsh, 2011).

The negative sign on the distance variable for the services equation is unexpected, mainly due to the type of service exports in Malaysia as it is primarily contributed by tourism. For example, in 2011, tourism contributed towards 55 percent for total services exports by 2011 (International Trade Centre (ITC), 2014). In the case of tourism, distance is a disadvantage as the further the distance, the higher the transportation costs between the two countries, the less the number of tourists expected. Also, services like communication, financial intermediation and business services (20.6 percent of total services exports from Malaysia in 2012) may lower transport costs (ITC, 2017). Overall, the study suggests that geographical distance does not only affect physical goods exports but also services exports.

A robustness test was also carried out using export data obtained from the OECD Trade in Value Added (TiVA) database (OECD 2017)[4]. We found that 70 percent of the coefficients have the same signs and similar significant levels in comparison with the results in Table 4.

6. Conclusion

This study examines the role of ICT in Malaysia's services and goods exports. It differs from previous studies as it is the first to explore the impact of ICT on services exports with the use of mirror data since data at the country level is not available. Unlike previous research, the present study examines ICT and FDI using network effects on goods and services exports. The results of the estimation using one-way trade data for goods and services separately are encouraging in that they provide strong support for the network effects of ICT on Malaysia's services exports. The study also showed FDI network has a significant but small impact on goods exports.

The results also have strong regional implications. The significant and negative impact of distance on both goods and services exports indicate the importance of enhancing connectivity for improving international transportation costs and reducing the negative impact of distance on international trade. In this regard, cooperating with regional initiatives on enhancing connectivity such as the ASEAN Connectivity Master Plan can provide an avenue for improving goods and services exports from Malaysia. This lesson is also applicable to Thailand. Being also a middle income economy that is also trade oriented, Thailand may hold a stronger advantage in terms of developing its ICT services trade due to its high performance in human capital (or ICT skills) in comparison to other ASEAN countries (Tee, Tham and Kam 2020).

Given that ICT has shown to facilitate exports of services between countries with the same level of ICT development, with strong human capital, Thailand can utilize this finding and consider a regional approach for using ICT to promote trade. Similar to Malaysia or other ASEAN countries, an important challenge for enhancing the export of services is to set out priority areas for regional cooperation and collaboration in ICT such as regulatory measures, infrastructure development and digital inclusion. Raising the

[4] Data of goods and services export from the Trade in Value Added (TiVA) database are also used as robustness check for the same model. The TiVA database was released for use to the public after the mirror data for this study was collected. A caveat is that, the TiVA data set only covers 38 countries for the period from 2000 to 2011 and has more gaps than the mirror data. Results from the test are in Appendix 1. It shows that the model is robust under different proxy variables as they are all statistically significant and has coefficient signs similar to Table 4.

level of ICT deployment in each country in the region will enhance Malaysia's exports of services to the region. Malaysia needs a sustained and enhanced regional cooperation program in ICT for mutual benefits.

Lastly, digitizing Malaysia will require enhanced efforts in collecting more and better data on ICT in the country. Admittedly, Malaysia is ahead of many developing countries in the construction of an ICT satellite account to monitor the impact of ICT on the economy. Nonetheless, the rapid changes in ICT itself dictate a review of how data is collected and the addition of new variables in keeping up with the times. This will also facilitate more studies on understanding the use of ICT and its impact on Malaysia's development through the trade channel.

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Appendix

Table A: Robustness Check. Estimation results using proxy from TiVA database

Variables	(i) Goods	(i) Services
GDP	1.04	1.00
	(0.03)***	(0.06)***
Distance	-1.07	-1.09
	(0.12)***	(0.16)***
Language	0.27	0.62
	(0.08)***	(0.26)**
FDI	0.04	0.03
	(0.02)***	(0.01)**
ICT	0.51	0.39
	(0.09)***	(0.10)***
Obs	330	332
R-sq: overall	0.90	0.89
Hausman	FE	RE#
# LM-Test (chi-bar^2)	-	667.73***
Correlation Max	0.58	0.61

Note: *** p<0.01, ** p<0.05, * p<0.1

A significant Breusch-Pagan Lagrange Multiplier test recommends the use of model RE