Australian Agricultural and Resource Economics Society (AARES)
54th Annual Conference

Adelaide, Australia

10-12 February 2010

Evaluating the Impacts of Information and Communication Technology (ICT) on Trade in Fruit and Vegetables within the APEC Countries

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Abstract

The global food marketing network is being constantly reshaped, providing opportunities and challenges to the use of information and communication technology (ICT) to develop international trade in food products. ICT is likely to be especially important for food products such as fresh fruit and vegetables that are differentiated and sensitive to timeliness in supply, possess varied quality dimensions, and involve considerable supply accumulation and assortment. Digital ICT (Internet and mobile phones), in particular, is expected to facilitate international trade and encourage efficiency in the fruit and vegetables marketing system in two main ways. First, it reduces communication and search costs through cheaper and more effective media. Second, it improves market information and corrects information externalities along the supply chain, by promoting greater price transparency and enabling consumer preferences and tastes to be more precisely met.

We employed a gravity model of international trade to test the hypothesis that ICT positively affects bilateral international trade in fruit and vegetables between member Asia-Pacific Economic Cooperation (APEC) economies in the period from 1997 to 2006. Explanatory variables include the usage of the Internet, mobile telephones and fixed telephone lines, and a broad range of factors that might determine the value of bilateral trade such as income per capita, population, distance between trading partners and common language. A Poisson pseudo-maximum likelihood model was estimated in order to handle zero trade observations and reduce biases caused by heteroskedasticity. Empirical results were not quite as expected, with relatively minor impact of digital ICT. They suggest that using digital ICT has significant positive effects on trade in fruit and vegetables between APEC countries only for the Internet in exporting countries. A stronger positive impact was discerned for the traditional form of ICT, fixed telephone lines in exporting importing countries. Nevertheless, fostering the development of digital ICT infrastructure and its diffusion should make exporters in APEC countries more competitive in the fruit and vegetables supply chain through the Internet effect, and boost their trade values in these products.

1. Introduction

Globalisation has been heavily shaped by the remarkable reduction in transport and communication costs from late 19th century to early 21st century. Baldwin and Martin (1999) classified globalisation into two different waves. The first wave was generated by technological innovation and infrastructure investment in transportation from the late 19th century. Consequently, oceanic shipping and train brought about cheaper and faster trade in goods. This trend was particularly important for trade in bulk commodities. The second wave of globalisation was caused by continued reductions in both transport and communications costs. Costs of oceanic shipping declined sharply from the post-war period to 1960. Airfreight costs also dropped but flattened out in the 1980s. Communication costs have continued their dramatic decline – an important example is the long-distance telephone call (Baldwin and Martin 1999) – leading Cairncross (1997) to discuss whether this development would cause the 'death of distance'.

We hypothesise that the new technological innovation in digital ICT (the Internet and mobile telephony) and the reduction of communication costs would have stimulated growth in international trade by lowering transaction costs and eliminating distance-related trade barriers. However, there is limited empirical research on the effects of digital communication technologies on trade flows. The existing literature typically focuses on transport costs and the effects of distance on trade (Fink, Mattoo and Neagu 2002). In this paper, we focus particularly on the use of digital ICT for trade facilitation in agriculture by firms along the traditional supply chain.

2. Background

2.1 Global value chain of the fruit and vegetables industry

The global food marketing network is being constantly reshaped by several factors, including shifts in demand and supply factors, greater consumer awareness of food safety, the emergence of global grades and standards, the application of food traceability systems, and concentration in the agribusiness value chain, particularly in respect of the rapid growth of supermarket chains (Huang 2004, Setboonsarng et al. 2009). These transformations have provided opportunities and challenges to the potential use of information and communication technology (ICT) to develop international trade in food products. They are likely to be especially important for

food products such as fresh fruit and vegetables that: are differentiated and sensitive to timeliness in supply; possess varied quality dimensions; and require considerable supply accumulation and assortment. For this reason, we focus on the effects of ICT on the trade flow of fresh fruit and vegetables from growers in exporting countries through exporters to the food retailers in the importing countries.

2.2 Previous studies of the effects of ICT on international trade

The most common ICT has traditionally been fixed line telephony, while the increasingly familiar digital ICT are the Internet and mobile telephony. Fixed telephone subscriptions are slightly in decline in most countries. Meanwhile, mobile telephony and Internet usage continue to increase rapidly in most countries. At the end of 2008, the number of mobile subscriptions and estimated number of Internet users in the world were 4 billion and 1.4 billion, respectively.

In developed countries, the introduction of 'triple play' service (telephone, Internet and television) is technologically supported by the fixed telecommunication infrastructure with an Internet protocol-based platform. In contrast, the low penetration of fixed telecommunications infrastructure will delay the development of ICT, and perhaps economic development in the developing world. For instance, the average penetration of broadband connectivity of developed countries is more than eight times greater than in developing countries. As a result, developing countries tend to adopt wireless technologies such as the third generation (3G) mobile telephony to prevent the emergence of a 'digital divide'. The mobile telephone is currently the most significant ICT for developing countries (UNCTAD 2008, 2009a).

The major function of ICT in facilitating agricultural trade is to improve the competitive advantage of corporations engaged in this trade by reducing barriers of entry and transaction costs, and thus expanding the global agricultural market. In general, the reduction of transaction costs is due to the reduction of communication costs, search costs and the improvement of business transaction efficiency.

The traditional agricultural marketing and export channels are often inefficient, where the agricultural seller (buyer) needs to go through multiple intermediaries and spend a large amount of time and money searching for information about buyers (sellers), products and prices. The powerful search engines available through the Internet can improve marketing efficiency by bringing together a range of global buyers and

sellers together to organise exchanges for electronic trade. Online business-to-business (B2B) e-markets have already been created in agricultural trade for a range of commodities such as coffee, tea, cotton and grains. For example, the online auctions of coffee in Brazil demonstrated a successful integration of ICT and traditional marketing channel for the development of coffee export. As well, Internet-based marketing of tea has been established in India (UNCTAD 2001, 2003). Also, mobile telephony and fixed line telephony enable the seller to communicate with the buyers or manage the customer relationship easily at low costs.

The conventional problem of information externality in agriculture can be resolved through the Internet, and perhaps mobile telephony. Based on the complex international marketing channel for agricultural products, price transparency along the supply chain is usually low. It can be enhanced through the Internet both domestically and globally (UNCTAD 2001, 2003). Moreover, significant market information on factors such as consumer preferences and agricultural supply conditions can be improved and disseminated over digital ICT cheaply and effectively.

Use of the Internet can reduce the costs of processing transactions, including getting cheaper trade-supporting services (finance, insurance, inventory management, distribution network, advertisement and even customer relationship management) online. The efficiency of the services can be improved through other communication technologies as well, including mobile phone (wireless technology) and fixed line telephony. Moreover, a global end-to-end monitoring of trade information of goods will be enabled by digital ICT. Both suppliers and consumers are able to monitor and track the goods at every point along the supply chain from the farm gate in exporting countries to the food purchasers in importing countries (UNCTAD 2001, 2003). This is important for the establishment of a food traceability system and an awareness of food safety.

In previous studies, Freund and Weinhold (2004) evaluated the effect of Internet diffusion by measuring the number of web hosts of a country, which suggested the growth of the number of web hosts by 10 percentage points increases the country's export growth by about 0.2 percentage points during 1995-1999. Fink, Mattoo and Neagu (2005) attempted to quantify the effect of communication costs on bilateral trade, both in terms of aggregate trade and across different product categories. Employing a gravity-type model and using the per-minute country-to-country calling

pricing as a proxy of international communication costs, they found that communication costs have a significant influence on bilateral trade patterns. Importantly, they suggested that trade in differentiated products benefits more from ICT than trade in homogeneous products, using the Rauch classification of product heterogeneity. In the specific area of agricultural trade, Wheatley and Roe (2005) used simple econometric methods to measure the positive effects of the Internet on exports and imports of agricultural and horticultural products in USA. Similarly, Clarke and Wallsten (2006) find that a higher Internet penetration will lead to higher aggregate exports from developing countries to developed countries; however, this case does not hold for trade between developing countries. As well, Clarke (2008) found a strong correlation between Internet connectivity and export at the enterprise level, although a reverse causality may be present between export performance and Internet access.

3. Analytical Method: The Gravity Model of Trade

Gravity models are commonly used to study bilateral trade flows in international trade, mainly because of their long history of empirical success. Tinbergen (1962) is a significant pioneer of the development of empirical modelling of the gravity model. Use of the gravity model was criticised during its early application in relation to its lack of theoretical foundations. But since Anderson (1979) began developing the economic theory for the gravity model based on product differentiation, further theoretical models have been developed, taking into account monopolistic competition, increasing returns to scale and expenditure systems (Law, Genc and Bryant 2009). Deardoff (1998) has shown that the gravity model can be based on many standard trade theories. Consequently, we employed it to explain bilateral trade patterns of fruit and vegetables in APEC countries, with the particular interest in investigating the effects of ICT on trade facilitation.

The principal idea of the gravity model to explain patterns in international trade comes from the gravity theory in physics – Newton's law of universal gravitation. In the model of international trade, the volume of trade is attributed to two major determinants: the economic mass of the exporting and importing countries and the distance between the trading countries (Law, Genc and Bryant 2009).

Conventionally, the basic gravity model can be written in logarithmic form as

$$\ln V_{ijt} = \ln G + \ln Y_i + \ln Y_j - 2\ln D_{ij} \qquad i = 1,\ldots, M, j = 1,\ldots,N \qquad (1)$$

where V_{ijt} is the level of trade (exports, imports or total trade) between countries i and j, Y_i is the economic mass of country i, Y_j is the economic mass of country j, D_{ij} is the distance between i and j, and G is the gravitational constant. The larger the values of Y_j and Y_j, the larger the values of V_{ij}. Conversely, D_{ij} has a negative relationship with the level of trade.

Using panel data, this model can be expressed as

$$\ln V_{ijt} = \alpha_i + \gamma_j + \lambda_t + \ln Y_{it} + \ln Y_{jt} + \ln D_{ij} + \ln \varepsilon_{ij} \quad t = 1,\ldots,T \tag{2}$$

where λ_t is the time effect and ε_{ijt} is a white noise disturbance term.

The interpretation of coefficients $\ln Y_{it}$ and $\ln Y_{jt}$ in equation (2) are the elasticities of trade with respect to the economic mass of exporting and importing countries, respectively. In empirical trade models, economic mass is typically represented by the gross domestic product (GDP) and population of the exporting and importing countries. The coefficient of $\ln D_{ij}$ is elasticity of trade with respect to the distance between country i and country j. α_i and γ_j are unobserved country-specific effects to account for the heterogeneity of trading countries, while λ_t indicates the unobserved year-specific effect. It is also common to extend the basic model of equation (2) by including a range of potential variables that may affect the flow of trade, such as geography, culture, language and political environment (Law, Genc and Bryant 2009). Some previous studies have categorised those factors as tangible and intangible barriers to trade (for example, Anderson and van Wincoop 2004).

4. Empirical Estimation and Data

4.1 Data definitions and description

We estimated a partial-equilibrium model of bilateral trade in fruit and vegetables among 20 of the 21 member countries of Asia Pacific Economic Cooperation (APEC) for the period from 1997 to 2006 (see Appendix Table A1 for a list of APEC members included in the analysis). Annual data of bilateral trade values of fruit and vegetables

are available in the UN COMTRADE database[1] in US dollars except for Taiwan; thus, Taiwan is the APEC member excluded from the analysis. We deflated the data on traded values using a deflator[2] with the base year of 2000, and entered the series in US$ million. The data set is a balanced panel that includes zero trade values.

The reasons for selecting the countries within APEC during the period from 1997 to 2006 for the analysis are fourfold. First, we have a particular interest in agricultural trade patterns within the Asia Pacific region. Second, Asia (East, Southeast and South) and the area of the North American Free Trade Agreement (NAFTA) are two of the three major production and consumption regions of the world trade in fruit and vegetables (the third is the European Union). Third, this regional trade bloc is located within a variety of climate zones (tropical, subtropical, temperate and Arctic). Finally, the countries of APEC consist of both developed and developing countries with a wide range of distances between them. As a result, a study of this regional trade bloc should be capable of reflecting the varied patterns of world trade in fruit and vegetables and the factors influencing these patterns.

A range of country characteristics exist in both the exporting and importing countries. They can be classified into sub-sets of time-varying and time-invariant variables for specifying the empirical model of trade in fruit and vegetables. Based on the expectation of the positive impacts of communication technology on trade facilitation, the sub-set variables of ICT are the indicators of access to the Internet, mobile telephony and fixed line telephony. These data are accessed from ITU (2008). The Internet and mobile telephony variables are digital technologies combining information and communication while fixed line telephony is a traditional communication tool. The Internet and mobile telephone were introduced in the mid-1990s, and were nearly globally available in 2006; therefore, our study period is based on the period from 1997 to 2006. Referring to Appendix Table A2, the percentage

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[1] In the UN COMTRADE database, data on fruit refer to the HS code 08 (edible fruit and nuts; peel of citrus fruit or melons) and data on vegetables refer to HS code 07 (edible vegetables and certain roots and tubers).

[2] The deflator used is the Gross Domestic Product: Implicit Price Deflator, obtained from the Bureau of Economic Analysis, U.S. Department of Commerce, which is available at the website, http://research.stlouisfed.org/fred2data/GDPDEF.txt

change of traditional communication technology of main telephone lines between 1997 and 2006 tended to flatten or slightly decline in the relatively 'rich' countries, with the exception of Canada; meanwhile, an upward trend is still present in most developing countries (UNCTAD 2009b). In contrast, according to Appendix Tables A2 and A3, the Internet and mobile telephony have a steep growing trend with a sharp percentage increase from 1997 until 2006 within the APEC countries, although the absolute penetration rates vary widely (see Appendix Table 4).

Two major hypotheses are tested to investigate the positive impacts of the sub-set of ICT variables on bilateral trade flows of fruit and vegetables in both exporting and importing countries. They are that these variables have a positive impact on export of bilateral trade in fruit and vegetables as group and individually.

Continuous variables of economic mass are fundamental to previous gravity models of bilateral trade flows. $GDPX_{it}$ and $GDPM_{jt}$ indicate the size of the economies of the exporting and importing partner countries, respectively, at time *t*. GDP data were obtained from UNCTAD (2009b). The size of the population in exporting and importing countries is another representation of economic mass, annotated as $POPX_{it}$ and $POPM_{jt}$ in year *t*, respectively. Population data were obtained from ITU (2008). In our analysis, we decompose total GDP into its component parts of population ($POPX_{it}$ and $POPM_{jt}$) and GDP per capita ($GDXC_{it}$ and $GDMC_{it}$) to represent economic mass. The reason for doing so is that GDP per capita is also a good proxy for the state of national infrastructure, which is likely to be an important factor influencing trade but which is very difficult to quantify as a variable in its own right.

We use two main explanatory variables from Egger (2000) and Baltagi, Egger and Pfaffermayr (2003) that are consistent with certain trade theories. First, $LSIM_{ijt}$ is a measure of economic size between the trading partner countries, in which Egger (2000) defines this variable as $\ln\left[1-\left(\frac{GDP_{it}}{GDP_{it}+GDP_{jt}}\right)^2-\left(\frac{GDP_{jt}}{GDP_{it}+GDP_{jt}}\right)^2\right]$. $LSIM_{ijt}$ implies countries with similar size of economic mass undertake a larger volume of trade with each other, although this theory may not be strongly hold for a specific industry such as fruit and vegetables. Second, Baltagi, Egger and Pfaffermayr (2003) defined $LRFAC_{ijt}$ as $\left|\ln\left(\frac{GDP_{it}}{capita_{it}}\right)-\ln\left(\frac{GDP_{jt}}{capita_{jt}}\right)\right|$. According to the classical Heckscher-

Ohlin-Samuelson trade theory, a positive sign is expected on the variables of $LRFAC_{ijt}$. Countries are willing to trade more with each other when their relative factor endowments, such as labour (horticulture is labour-intensive) and natural resources (such as water and land) differ. In contrast, the 'new trade theory' suggests scale economies and product differentiation of international trade would lead to a negative relationship between the variables of $LRFAC_{ijt}$ and the value of trade (Baltagi et al. 2003). Fruit and vegetable products are bulky and highly perishable, and often need to be transported long distances when they are traded internationally. These attributes mean that transport costs are likely to influence trade volumes. We attempt to capture these effects over time by including the variable, $FUEL_t$, defined as the mean annual Brent crude oil price in real terms.

A sub-set of time-invariant country-specific variables is usually included in trade gravity models. Examples are geographic factors, such as distance and conmon borders, common language, and the political and business environment. $DIST_{ij}$ is an indicator of distance between trading countries which is taken from the extensive set of variables made available online by CEPII (see http://www.cepii.fr). $LANG_{ij}$ is included as a binary variable that takes the value of one if trading partners share a common language. ADJ_{ij} is included as a binary variable that takes the value of one if trading partners share a common border.

Descriptive statistics of selected variables included in the empirical model are presented in Appendix Table A5. They reflect the wide ranges in values of fruit and vegetables traded and the set of explanatory variables. The range of penetration rate for all three ICT variables is wide among APEC countries. For instance, the rates of Internet use per 100 inhabitants vary from zero users in the beginning of the study period, particularly in the transitional and developing countries, to more than 80 users per 100 inhabitants in developed countries towards the end of the study period.

4.2 Empirical estimation of the gravity model

We employed the Hausman test to evaluate the choice between a fixed-effects or random-effects model Test results indicate that a two-way fixed-effects model is the preferred estimator. This conclusion is consistent with the suggestion made by Cheng and Wall (2003) to use a general fixed-effects model to eliminate the bias of country-pair heterogeneity. A drawback of the fixed effects estimator is that it is not capable

of estimating coefficients of variables that are time-invariant, such as distance, common language and common national boundaries.

Despite the gravity model being commonly used empirically, some econometric problems have emerged in its estimation. First, the conventional use of logarithmic transformation is likely lead to the underprediction of large trade flows and total trade flows. In addition, the log-normal model is unable to deal with the zero trade flows because the logarithm of zero is undefined. Besides, heteroskedasticity tends to exist in the large number of cross-sections in a panel data series used to estimate an international trade model. The condition of equal variance of the error terms is violated where the country-specific variables are omitted (Linders, Burger and van Oort 2008). Because the presence of heteroskedasticity leads to highly misleading coefficients in gravity models, steps need to be taken to minimise bias.

To overcome the problems of the gravity model highlighted above, we employ the Poisson pseudo-maximum likelihood (PPML) fixed-effects model introduced by Santos Silva and Tenreyro (2006). First, Poisson specification has a log-linear linking function rather than a log-log function; as a result, the estimation avoids the under-prediction of large value or volume of trade where the trade is measured in levels. Second, the Poisson model is estimated by a maximum likelihood method in which the sum of the predicted values is identical to the sum of the input value. Third, the Poisson regression provides a natural way to deal with the difficulty of zero-trade flows because of its non-linear form by using an exponential regression function (Linders, Burger and van Oort 2008). A detailed explanation of the Poisson specification of the gravity model trade can be found in Santos Silva and Tenreyro (2006). The two-way fixed-effects (time dimension and time-invariant trading country effects) model suggested by Anderson and van Wincoop (2003) is combined with the use of a PPML model. As a result, the problem of heteroskedasticity and misspecification of variables could be simultaneously solved. We estimate the PPML fixed-effects model using the econometric package, STATA.

Next, we assume geographical distance is still significant for the explanation of international trade patterns, as mentioned above. We capture the effect of distance through the country-pair fixed effects specification. Because of our particular interest in ICT variables and the effect of distance on their importance, we generate six interaction variables where a dummy variable is generated that takes the value of 1 if

the value of $DIST_{ij}$ is greater than the mean distance between trading partners across the sample. This dummy variable is then multiplied by the sub-set of ICT variables. International trade is largely based on promises, trust and reputation, which do not travel easily over long distances. Because ICT can help to reduce this friction, we expect positive coefficients on these interaction variables.

The model specification is:

$$\ln VALUE_{ijt} = \alpha_i + \gamma_j + \lambda_t + \beta_1 \ln POPX_{it} + \beta_2 \ln POPM_{jt} + \beta_3 \ln GDXC_{it} +$$

$$\beta_4 \ln GDMC_{jt} + \beta_5 \ln SIM_{ijt} + \beta_6 \ln LRFAC_{ijt} + \beta_7 \ln FUEL_t + \beta_8 \ln TELX_{it}$$

$$+ \beta_9 \ln MOBX_{it} + \beta_{10} \ln NETX_{it} + \beta_{11} \ln TELM_{jt} + \beta_{12} \ln MOBM_{jt} + \beta_{13} \ln NETM_{jt}$$

$$+ \beta_{14} DIST\ (\ln TELX_{it}) + \beta_{15} DIST\ (\ln MOBX_{it}) + \beta_{16} DIST\ (\ln NETX_{it}) + \beta_{17} DIST$$
$$(\ln TELM_{jt}) + \beta_{19} DIST\ (\ln MOBM_{jt}) + \beta_{20} DIST\ (\ln NETM_{jt}) + \varepsilon_{ijt} \qquad (3)$$

Definitions of the variables are presented in Appendix Table A6. Using the results of likelihood ratio tests, we conclude that the estimation of equation (3) using PPML fixed-effects estimator is the most appropriate model specification. Estimates of coefficients in equation (3) are made using the PPML fixed-effects estimator. Following Westerlund and Wilhelmsson (2007), standard errors are estimated by using the bootstrapping option in STATA. Results are presented in Table 1.

5. Discussion of Results

5.1 ICT variables

The coefficients of the ICT variables in this study accord with our expectations having a positive sign, except for the variables of mobile phone. The penetration of fixed telephone lines in exporting countries has a significantly and positive impact on trade values of fruit and vegetables between trading partners. A 1 per cent increase in fixed telephone penetration will increase the value of trade by 0.360 per cent. The coefficient on telephone penetration in importing countries is not significantly different from zero at the usual significance levels.

In relation to the digital ICT variables, a 1 per cent increase in Internet users in exporting countries will stimulate the value of trade in fruit and vegetables between

trading partners by 0.166 per cent. The coefficient on Internet penetration in importing countries is not significantly different from zero. Coefficients of mobile phone subscription in exporting and importing countries are also both statistically insignificant.

Table 1 Regression Estimates of the Gravity Model

Explanatory variable	Coefficient	Standard error	*t*-value	*p*-value
$LPOPX_{it}$	1.408	1.871	0.750	0.452
$LPOPM_{jt}$	1.462	1.130	1.290	0.196
$LGDXC_{it}$	0.430	0.194	2.210	0.027
$LGDMC_{jt}$	1.071	0.217	4.930	0.000
$LSIM_{ijt}$	16.798	15.842	1.060	0.289
$LRFAC_{ijt}$	2.477	2.095	1.180	0.237
$LFUEL_{t}$	-0.125	0.065	-1.920	0.055
$LTELX_{it}$	0.360	0.161	2.240	0.025
$LMOBX_{it}$	-0.085	0.101	-0.850	0.397
$LNETX_{it}$	0.166	0.072	2.300	0.021
$LTELM_{jt}$	0.155	0.372	0.420	0.677
$LMOBM_{jt}$	-0.037	0.122	-0.310	0.760
$LNETM_{jt}$	0.002	0.096	0.020	0.984
$DLTELX_{it}$	-0.080	0.260	-0.310	0.758
$DLMOBX_{it}$	0.025	0.119	0.210	0.835
$DLNETX_{it}$	-0.130	0.093	-1.400	0.162
$DLTELM_{jt}$	0.088	0.476	0.180	0.854
$DLMOBM_{jt}$	0.048	0.159	0.300	0.762
$DLNETM_{jt}$	-0.051	0.113	-0.045	0.652
Log likelihood	-7515.938			

The above estimates indicate that positive impacts of ICT on trade value in fruit and vegetables occur only in the exporting countries. No effect is evident in importing countries. The positive impact of the penetration of ICT in exporting countries may be

attributed to the benefits of ICT on trade discussed above. Likely important factors include increasing demand for an effective food traceability system, greater awareness of food safety, and the need to be able to respond quickly at this end of the supply chain to variations in seasonal and regional production of fresh fruit and vegetables. However, the extent or size of the positive impacts of ICT on trade in fruit and vegetables are smaller than our expectations. We now attempt to provide reasons why this might be so.

The small magnitudes and lack of significance of coefficients of the six interaction variables suggest that ICT does not play a major role in reducing the effects of distance in international trade in fruit and vegetables.

The growth of trade in fruit and vegetables is limited by the characteristic of perishability. The time-consuming and long-distant transportation of fresh fruit and vegetables trade consists of a relatively high marketing cost from the farm gate in the exporting country to food retailers in importing countries, although the costs of transportation, storage, and packaging are being brought lower with continuing innovation such as cool chain management and modern containers. This suggests the continuing importance of distance and transportation on global agricultural trade patterns. The market creation effect on international trade in fruit and vegetables by ICT is brought about the requirements of food safety and standards. It is arguable that the concentration of the global food marketing chain (from farmers of the exporting countries to food retailers of the importing countries) decreases the potential for beneficial effects of ICT on trade. The major players in the fresh fruit and vegetables value chain will tend to reap larger benefits from ICT in a more competitive industry.

In relation to corporate use of the Internet, the small effects of the Internet on trade facilitation suggest enterprises are still learning to capture the benefits of digital ICT to their business. In addition, firms in the developing economies are lagging in their Internet use in business compared with firms in the developed world (UNCTAD 2001). For instance, results indicate that the positive impacts of fixed telephone in exporting countries are larger than the benefits of the digital communication technology. This may reflect slowness in learning new technologies considering the relatively new technologies of the Internet and mobile phone. UNCTAD (2005) observed that most enterprises in developing countries use the Internet only for basic information search and e-mailing without broadband access. As a result, some

enterprises are incapable of using the Internet for advanced e-business activities, such as banking, financial services and dealing with government forms. Security and privacy of transactions are apparently an obstacle to the advanced use of the Internet for trade, such as financial and credit transactions (Daly and Miller 1998). As well, Leamer and Storper (2001) discussed the limitations of the Internet for conducting business activities. Economic activity depends on the transmission of complex uncodifiable messages based on understanding and trust. Digital conversations through the Internet may not be able to support the deep and complex contacts for customer relationship management of export and import activities brought about by factors such as culture, language and history.

Diffusion of new ICT for business use depends on competition and pricing of the telecommunication infrastructure (for example, telephone networks) and service (such as long-distance telephone services and Internet access). In many countries, telecommunications are still protected, monopolised or state-owned. Lack of competition in telecommunication infrastructure and services is caused by three characteristics of a communication network: 1) low marginal costs and high fixed costs, 2) the nature of quasi-public goods with the characteristics of natural monopoly and congestion effects, and 3) the existence of network externalities (Harris 1995). For instance, the international component of the Internet backbone only represents a small part of the total costs of Internet service providers (ISPs), where the costs are mainly determined by the domestic ISPs (UNCTAD 2005). In a previous study of Internet competition, Wallsten (2003) found that removing entry barriers (ISP licensing) and promoting ISP competition may lead to a low-cost and non-distortionary market for increasing Internet use in developing countries. Galbi (1998a) discovered the presence of cross-border rent shifting of international telephone calls between the bilaterally domestic countries for mutual benefits. Galbi (1998b) suggested the distinction between international and domestic interconnection arrangements will be eased under a new pricing structure of international telephone calls. To maximise the effect of telecommunication on the world economy, the world market of communication in both hardware and services needs to be liberalised. Competition in the telecommunication market can suppress the premium price of charging and provide a range of choice of telecommunication services for customers with better quality (Cairncross 1997). Governments can liberalise the

telecommunications market though licensing new telecommunication service providers and creating an independent regulatory body for monitoring a fair and competitive telecommunication market (UNCTAD 2002), thus boosting the number of ICT users and indirectly fostering trade.

Apart from the considerations of the industries involved in trade in fruit and vegetables and the ICT industry, the effective use of ICT by customs authorities in both exporting and importing countries could affect the benefits of digital and traditional communication technology to trade. The effectiveness of customs is determined by customs custody and regulations, customs procedures and tariff classification systems, valuation of exports and imports, transparency of regulations, administration (physical infrastructure and human resources), and even the intensity of corruption, where an ineffective customs would lead to delays, high costs and inefficiencies of export and import (UNCTAD 2001).

Finally, the content of the data series of ICT variables may not accurately represent the use of ICT by business. There may be a need for micro-level studies of the availability and use made of data by businesses involved in the horticultural industry, particularly by those in developing countries (UNCTAD 2008).

5.2 Other variables

The coefficients of the basic variables of gravity model (economic mass and distance) are consistent with the theory of gravity model. Both the coefficients of population and GDP per capita in the exporting and importing countries have an expected positive sign. Coefficients of GDP per capita are significant while the coefficients of population are statistically insignificant. The coefficient of fuel costs has an expected negative sign and is statistically significant at the 5 per cent significance level using a one-tail test. A 1 per cent increase in this proxy of transport costs will diminish the trade value of fruit and vegetables by 0.125 per cent. The negative correlation of transport cost and trade flows implies the constraints of distance on trade growth.

The coefficients of $LSIM_{ijt}$ and are not significant at the usual significance levels. These results mean that we cannot draw any conclusions about the willingness of countries of similar economic size to trade in fruit and vegetables with each other. Or the relative merits of the Heckscher-Ohlin-Samuelson theory and the ‘new trade theory’ in influencing trade in fruit and vegetables among APEC countries. It is

possible that trade is encouraged by both differences in factor endowments as well as by product differentiation and scale economies.

6. Conclusions

We employed a gravity model of international trade to test the hypothesis that ICT positively affects bilateral international trade in fruit and vegetables between member APEC economies during the period from 1997 to 2006. Of particular interest was the impact of usage of the Internet, mobile telephones and fixed telephone lines on the volume of trade. In addition to these variables, a broad range of factors that might determine the value of bilateral trade were specified, including income per capita, population, distance between trading partners and common language. A Poisson pseudo-maximum likelihood model was estimated in order to handle zero trade observations and reduce biases caused by heteroskedasticity.

Empirical results were not quite as expected, with a relatively minor impact of digital ICT observed. They suggest that using digital ICT has significant positive effects on trade in fruit and vegetables between APEC countries only for the Internet in exporting countries. A stronger positive impact was discerned for the traditional form of ICT, fixed telephone lines, in exporting countries. Nevertheless, fostering the development of digital ICT infrastructure and its diffusion should make exporters in APEC countries more competitive in the fruit and vegetables supply chain through the Internet effect, and boost their trade values in these products.

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Appendix Table A1 Countries of APEC Included in the Analysis

Country	Year of joining
East Asia	
China (People's Republic of)	1991
Hong Kong SAR, China	1991
Japan	1989
Korea (Republic of)	1989
South East Asia	
Burundi (Republic of)	1989
Indonesia (Republic of)	1989
Malaysia	1989
Philippines (Republic of the)	1989
Singapore (Republic of)	1989
Thailand	1989
Viet Nam (Socialist Republic of)	1998
Oceania	
Australia	1989
New Zealand	1989
Papua New Guinea	1993
Latin America	
Chile	1994
Mexico	1993
Peru	1998
North America	
Canada	1989
United States of America	1989
Eastern Europe	
Russian Federation	1998

Source: APEC Home Page

Appendix Table A2 Fixed Telephone Lines in Use per 100 people in APEC Countries, 1997-2006

Country	1997	2006	% change
Upward trend			
Viet Nam	1.77	32.23	94.51
China	5.66	22.79	75.16
Indonesia	2.47	6.57	62.40
Mexico	9.69	18.33	47.14
Russian Federation	19.13	30.80	37.89
Philippines	2.87	4.30	33.26
Thailand	8.09	10.92	25.92
Peru	6.75	8.46	20.21
Korea	45.26	49.82	9.15
Chile	18.42	20.20	8.81
Canada	62.21	64.49	3.54
Downward trend			
Japan	52.13	43.02	-21.18
Brunei	25.01	20.99	-19.15
Malaysia	19.49	16.83	-15.81
United Sates	63.77	55.63	-14.63
Papua New Guinea	1.16	1.02	-13.73
New Zealand	46.98	44.06	-6.63
Singapore	44.41	42.32	-4.94
Hong Kong	56.19	53.89	-4.27
Australia	50.30	48.81	-3.05

Source: ITU 2008

Appendix Table A3 Mobile Telephone Subscribers per 100 People in APEC Countries, 1997 and 2006

Country	1997	2006	% change
Russia	0.33	105.71	99.69
Vietnam	0.21	18.17	98.84
Indonesia	0.45	28.30	98.41
China	1.07	34.83	96.93
Mexico	1.82	52.63	96.54
Philippines	1.86	50.75	96.33
Chile	2.80	75.62	96.30
PNG	0.08	1.67	95.21
Peru	1.73	30.91	94.40
Thailand	3.70	62.88	94.12
Malaysia	9.23	75.45	87.77
New Zealand	14.97	93.99	84.07
Korea	15.25	83.77	81.80
Brunei	14.66	78.92	81.42
Singapore	22.37	109.34	79.54
Canada	13.99	57.57	75.70
United Sates	20.29	80.32	74.74
Australia	24.63	97.02	74.61
Hong Kong	34.36	132.68	74.10
Japan	30.33	79.32	61.76

Source: ITU 2008

Appendix Table A4 Internet Users per 100 People in APEC Countries, 1997 and 2006

Country	1997	2006	% change
China	0.03	10.35	99.71
Peru	0.41	22.89	98.21
Philippines	0.14	5.92	97.64
Russia	0.47	18.02	97.39
Mexico	0.62	18.98	96.73
Indonesia	0.19	4.69	95.95
Chile	1.07	25.24	95.76
Malaysia	2.31	54.23	95.74
Thailand	0.63	13.07	95.18
Korea	3.62	71.11	94.91
PNG	0.11	1.83	93.99
Brunei	4.89	41.69	88.27
Japan	9.16	68.27	86.58
Australia	8.61	52.05	83.46
New Zealand	14.54	78.77	81.54
Canada	15.00	76.77	80.46
Hong Kong	10.40	52.97	80.37
Singapore	13.18	59.36	77.80
United Sates	22.01	69.83	68.48
Vietnam	0.00	17.21	NA

Source: ITU 2008

Appendix Table A5 Descriptive Statistics of the Selected Variables in the Estimation

Variable	Mean	Maximum	Minimum
VALUEijt	36939314	4000000000	0
GDPXit	974762	11295853	3296
GDPMjt	974762	11295853	3296
POPXit	128171	1323636	344
POPMjt	128171	1323636	307
DISTij	8472	19471	185
FUELt	31	65	13
TELXit	29	68	1
MOBXit	36	133	0
NETXit	23	79	0
TELMjt	29	68	1
MOBMjt	36	133	0
NETMjt	23	79	0

Appendix Table A6 Definitions of the Main Variables Used in the Analysis

Variable	Definition
VALUEijt	Value of trade in fruit and vegetables between country *i* and country *j* (USD) at time *t*
GDXCit	Gross domestic product per capita of exporting countries (USD million) at time *t*
GDMCjt	Gross domestic product per capita of importing countries (USD million) at time *t*
POPXit	Population of exporting countries in thousands of people at time *t*
POPMjt	Population of importing countries in thousands of people at time *t*
FUELt	Mean annual Brent crude oil price in real terms (USD) at time *t*
DISTij	Distance between country *i* and country *j* (kilometres) at time *t*
TELXit	Main telephone lines in use per 100 inhabitants in exporting countries at time *t*
MOBXit	Mobile cellular telephone subscribers per 100 inhabitants in exporting countries at time *t*
NETXit	Internet users per 100 inhabitants in exporting countries at time *t*
TELMjt	Fixed telephone lines in use per 100 inhabitants in importing countries at time *t*
MOBMjt	Mobile cellular telephone subscribers per 100 inhabitants in importing countries at time *t*
NETMjt	Internet users per 100 inhabitants in importing countries at time *t*
LSIMijt	$\ln\left[1-\left(\frac{GDP_{it}}{GDP_{it}+GDP_{jt}}\right)^2-\left(\frac{GDP_{jt}}{GDP_{it}+GDP_{jt}}\right)^2\right]$
LRFACijt	$\left\lvert\ln\left(\frac{GDP_{it}}{capita_{it}}\right)-\ln\left(\frac{GDP_{jt}}{capita_{jt}}\right)\right\rvert$