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Contribution of ICT to the Vietnamese Economy: An Input-Output Analysis

Dang Thi Viet Duc[1,*], Dang Huyen Linh[2]

[1]*Posts and Telecommunications Institute, Vietnam, Km 10, Nguyen Trai Str., Hanoi, Vietnam*
[2]*Vietnam Institute for Development Strategies, Ministry of Planning and Investment, Vietnam, 65 Van Mieu Str., Hanoi, Vietnam*

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Abstract: This article uses Input-output (IO) analysis to evaluate the impact of ICT on the Vietnamese economy. Two IO tables are used, including tables from 2007 and 2012. The results show that ICT sectors were small in the Vietnamese economy and the spending on ICT products and services of an average sector of the economy was generally low. Regarding the impact on the output of other sectors, the research results reveal that ICT services and ICT media and content had an increasingly stronger link in production with other economic sectors of the economy. In contrast, the dispersion effect of the ICT manufacturing sector fell; despite this fact, ICT manufacturing retained a strong impact on the economy. In general, the impact of ICT was not much higher than other non-ICT sectors in Vietnamese economy. Results also reveal that the ICT sectors' backward linkages were stronger than forward linkages, i.e. the ICT sectors generated more impact on sectors which provided it input rather than on sectors that used its products and services. The study implies that if Vietnam seeks to enhance the economy, the government needs to implement specific policies that facilitate ICT industry and ICT usage.

Keywords: Backward linkage, forward linkage, ICT, output multiplier, Vietnam.

1. Introduction

Economists have long recognized that information and communication technology (ICT) is one of the most important forces driving the economic growth of the economy [1-4]. The impact of ICT on economic growth lies not only in the increasing contribution of the sectors' own output to the economy, but more importantly, the application of ICT products and services in other sectors of the economy leads to new products, changes in business models and processes, higher labor productivity, ultimately leading to high economic growth.

Although economists are no longer doubting the importance of ICT in the economy, they also note that the ICT development and its impact in the economy is a process [3-5]. Thus, ICT diffusion and its impact on economies are differently regarding in different periods and in different geographical configurations of the economy. The effect of ICT on the economy is expected

* Corresponding author. Tel.: 84-914932612.
Email: ducdtv@ptit.edu.vn

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to be higher in developed countries than in developing countries. Measurement of ICT usage and the impact of ICT on the economy is a means for identifying the ICT development phase, thus suggesting the direction of the sector in the future.

In Vietnam, since the 1990s the government has developed national policies and programs for information technology. The national IT Resolution 49/CP released by the Government in the 1990s [6] and Directive 58/TW [7] issued by the Vietnamese Communist Party Central Committee, the highest level in the political system of Vietnam, asserted that ICT should be the future and the means of the Vietnamese economy. More recently, Decision 392/QĐ-TTg issued by the Prime Minister in 2015 [8] to approve the program to develop the information technology industry to 2020 with a vision to 2025 asserts the Vietnamese government's strong commitment to the development of ICT. As such, ICT has always been considered as an engine of economic development in Vietnam, but the quantitative impact of ICT on growth and economic development has never been studied.

The objective of this paper is to assess the contribution of ICT to the Vietnamese economy and to see if this contribution is distinct compared to that of other sectors. For this objective the article uses IO tables to analyze the relation between ICT and other economic sectors, i.e. ICT is examined both as an input provider and output user of other sectors, through which to evaluate the impact of ICT on the entire economy. To be more specific, the paper analyzes the input and output structure of ICT sectors, the share of ICT input in the total input of each economic sector, the backward linkage and the forward linkage as well as the output multiplying effect of ICT in the Vietnamese economy. The article contributes to the literature on the impact of ICT across countries, and provides some implications for the sector development policy for economic development in Vietnam.

The article is organized as follows. After the introduction, the article goes on to examine the role of ICT in the economy on the theoretical and empirical aspects. Section 3 describes the methodology and data used in the research. Section 4 presents the results and discussion of the study and section 5 is the conclusion.

2. Literature review on the role of ICT in the economy

Solow, in his calculation in 1957, demonstrated that half of the economic growth of the USA economy in the first half of the 20th century could be explained by increases in neither capital nor labor, but in technological knowledge [9]. Becker (2003) points out that "from 1995 to 2000, almost all of the improvements in productivity (in the USA) were either due to investments in information technology or advances in the output of information technology related goods" and asserts that the effect of the IT revolution was only beginning to be felt [2]. ICT is seen as a driver of modern economic growth and development and is also the driver of new economic phenomena and concepts such as the knowledge economy, the information economy and the digital economy.

Theoretically, there are two known models that explain the significant role of ICT in the economy and the development of an ICT-based economy. The first model was developed by some neo-classical economists such as Helpman (1998) [1] and Bresnahan and Trajtenberg (1992) [10], who view ICT as a general-purpose technology (GPT). Unlike conventional technologies, general-purpose technologies have three distinct characteristics: pervasiveness, improvement, and innovation spawning. "Pervasiveness" means that the GPT is used as an input for many manufacturing and service industries through which its influence diffuse in the economy. "Improvement" indicates the scope for improvement, experimentation and elaboration and the continuously falling costs of GPT. And

"innovation spawning" exists because the application of GPT to manufacturing and service industries supports the creation of new products and new production processes [10]. The authors compare ICT with other general purpose technologies that the world economy has experienced such as printing technology, the steam engine, mechanization, railways, electricity, etc. to see the impressive impact of ICT on the economy.

The second model examines the role of ICT through the concept of a "technological paradigm" [3, 4, 11]. A technological paradigm includes a set of basic technologies created and directed by specific principles and practical rules. The basic technological group as a "paradigm" must have a breakthrough effect, not only in terms of technical aspects but also the structure of the organization and management which actually constitutes a revolution that changes the whole logic of production and economy. Shiller (2000) and Freeman (2005) call the "ICT paradigm" the new economy [5, 4]. ICT requires companies to change their organizational structures, the interactions within their organizations, as well as the way they interact with partners, suppliers and customers so that companies can continue to exist and compete in the market. ICT affects the way people live and work. And finally we have a whole new economic order of the economy. The ICT technological paradigm theory assures that the impact of ICT is comprehensive both in quality and quantity, both in the structure of the techno-economic system and the socio-institutional system of the economy.

Both the general-purpose technology model and the ICT technological paradigm theory confirm the deep and broad impact of ICT in the economy. Therefore, the assessment of the impact of ICT on economic growth and development should always take into consideration the pervasiveness and the structure change effects of ICT on other economic sectors. Both models also confirm that ICT requires large adjustments from the economy to realize its impact. Thus, the impact of ICT is dependent on stages of ICT development in a country and across countries.

Many empirical studies have been done to assess the importance of ICT to the economy of different countries. From a macroeconomic perspective, there are two main methodological approaches including parametric (such as econometric techniques) and non-parametric (such as growth accounting). Econometric techniques estimate parameters of a production function using a regression model. Growth accounting attributes growth in GDP to increases in physical inputs and advances or improvements in production technology. Input-output (IO) matrices can be used to calculate the multiplier effects of ICT. Although most empirical studies on this issue conclude the positive effect of ICT on an economy, they produce mixed results on whether ICT generates a distinctive effect in comparison to other sectors.

Studies such as Bazzazan (2009), Keček et al. (2016) or Irawan (2013) show that the impact of ICT on growth and productivity of the economy is indifferent and not superior to that of other sectors [13-15]. Bazzazan (2009) evaluates the impact of ICT on the economy of Iran [13]. The author divides the economy into six major sectors, and the results show that from the demand side the ICT sector is placed in the fourth rank among six sectors and accounts for 8.6% of the total output, and from the supply side, ICT is also placed in the fourth rank with an economic contribution of 9.5% of the total output of the economy. Keček et al. (2016) investigates the role of ICT in the Croatian economy [14]. The results indicate that there is no difference in ICT's output multiplier over those of other sectors. Moreover, the productivity index of the Croatian ICT sector has not changed much between 2004 and 2010. Irawan (2013) compares the ICT sector's impact on the economies of some Asian countries through indicators such as the output multiplier, income multiplier, backward linkage, and forward

linkage of the ICT industry [15]. The results show that the output multipliers of ICT are greater than 1. However, the study also points out that only the ICT service sector of Malaysia and the ICT manufacturing sector in Thailand are distinct from other sectors in terms of output multiplying impact on the economy. In most other cases, the ICT sector does not show any impact difference in comparison with other sectors of the economy.

In contrast, some others point out a more distinct impact of ICT on the economy compared with other sectors. The Ministry of Communications and Information Technology of India (2005) calculates the output multipliers of the ICT industry in the Indian states [16]. The results show that on average a unitary increase of output produced by the Indian ICT industry leads to an increase of 2.3 units in the total output of the economy. Analysis in Heng and Thangavelu (2010) finds that the use of ICT is generally pervasive in the Singaporean economy and a 10% decline in information input prices causes a positive 0.84% increase in the national income [17]. Kretschmer (2012) reviews some empirical works on the impact of ICT on productivity growth and indicates that the productivity effect of ICT is not only significant and positive, but is also increasing over time [18]. They find strong evidence that ICT is a GPT based on the United States data, although it is difficult to find evidence in Europe. Van Ark et al. (2008) compares the contribution of ICT to the economic growth of some European countries. The results indicate that Finland and Germany gain greater economic impact from ICT compared with other European countries [19].

3. Methodology and data

Leontief (1986) developed and presented input-output models as quantitative economic techniques for economic analysis. Input-output tables record transactions between economic sectors, each producing a product and at the same time consuming products from other industries [20]. A table consists of three basic quadrants (Figure 1). Quadrant I represents intermediate inputs by columns and intermediate demands by rows. Quadrant II represents the final demands of the economy which consists of household final demand, government final demand, accumulated assets and export minus import. Quadrant III expresses primary input or value added of the economy which includes worker's income, fixed asset depreciation, production tax, and surplus value.

The advantage of the IO method is the ability to analyze the impact of ICT both directly and indirectly, at both the macro and the industry levels. The transactions in quadrant I of the IO table are recorded and synthesized based on the national survey data.

To operationalize the method, assume that the economy has four sectors. Quadrant I is a square matrix:

Intermediate transactions Intermediate demand/intermediate input I	Final demand II	Total output
Primary input/value added III		
Total input		

Figure 1. Input-output (IO) table.
Source: Adopted from Leontief (1986).

$$\begin{bmatrix} X_{11} & \cdots & X_{14} \\ \vdots & \ddots & \vdots \\ X_{41} & \cdots & X_{44} \end{bmatrix}$$

Where X_{ij} denotes the output of sector i used by sector j as an intermediate input.

Quadrant II - the final demand matrix and quadrant III- the value added matrix are expressed as follows:

$$F = \begin{bmatrix} F_1 \\ \vdots \\ F_4 \end{bmatrix}, V = [V_1 \quad \dots \quad V_4]$$

Where F_i refers to the total final demand of sector i whereas V_j refers to the added value of sector j.

The total output of the economic sectors is represented by the matrix:

$$X = \begin{bmatrix} X_1 \\ \vdots \\ X_4 \end{bmatrix}$$

Where X_i denotes the total output of sector i.

From the intermediate transaction matrix, it is possible to calculate the technology matrix A.

$$A = \begin{bmatrix} a_{11} & \cdots & a_{14} \\ \vdots & \ddots & \vdots \\ a_{41} & \cdots & a_{44} \end{bmatrix} \quad (1)$$

Where $a_{ij} = \frac{x_{ij}}{x_j}$. Technology matrix A represents the ratio of intermediate input to total output of industry j.

To assess the ICT inputs in other sectors, the matrix of ratios of intermediate-input from sector i to total intermediate input of sector j is calculated. This matrix is expressed as follows:

$$D = \begin{bmatrix} d_{11} & \cdots & d_{14} \\ \vdots & \ddots & \vdots \\ d_{41} & \cdots & d_{44} \end{bmatrix} \quad (2)$$

Where $d_{ij} = \frac{a_{ij}}{a_{.j}} \times 100$

Next, the equilibrium of the equation for supply and demand of the economy is expressed by the formula:

$$AX + F = X \quad (3)$$

By transforming the formula we have:

$$X = (I - A)^{-1}F \quad (4)$$

The inverse Leontief matrix $(I - A)^{-1}$ represents the output multiplier of the economy. From this matrix, it is possible to identify how a certain economic sector affects the total output of the economy. In this study the output multiplier is calculated from the open IO tables instead of the closed one. An open IO consists of production process leaving consumption exogenous. The open IO model is closed by adding an endogenous sector, namely households whose inputs are given by the consumption column in the transactions matrix. Grady and Muller (1988) show that the use of a closed IO table usually yields exaggerated estimates of the impact [21].

The inverse Leontief matrix also helps to identify the backward linkages and forward linkages of a sector [22, 23]. Backward linkage is used to measure the importance of an industry as the user of physical goods and services as an input from the whole economy. Backward linking is called the index of the power of dispersion and is defined as follows:

$$\text{Backward Linkage} = \frac{n.BL_j}{\sum BL_j} \quad (5)$$

Where $BL_j = \sum_i r_{ij}$, r_{ij} is the element of the Leontief matrix, n is the number of sectors in the model.

Forward linkage implies the importance of an industry as a source of physical goods and services for the entire economy. This linkage is considered as the sensitivity of dispersion of the economy and is calculated as follows:

$$\text{Forward Linkage} = \frac{n.FL_i}{\sum FL_i} \quad (6)$$

Where $FL_i = \sum_j r_{ij}$, r_{ij} is the element of a Leontief matrix, n is the number of sectors in the model.

The above (4) mentioned the so-called Type $(I - A)^{-1}$ or competitive IO model. In the competitive IO table, the intermediate inputs include both commodities produced domestically and imported. The competitive IO tables are simple, but less precise for real domestic economic analysis.

In non-competitive IO tables, the intermediate inputs are broken down into commodities produced domestically and commodities imported from the rest of the world. In contrast to the competitive IO table, a non-competitive table with imports clearly separated from intermediate inputs produced domestically, and thus with two intermediate input coefficient matrix A^d (domestic A) and A^m (import A), will give the users a much better picture of the economy.

Since the non-competitive IO tables are not readily available in many cases, i.e. it is not feasible to separate commodities produced domestically and commodities imported in the intermediate inputs, another type of IO model, called $(I - (I - \hat{M})A)^{-1}$ type, can be calculated and used to exclude the impact of import in the domestic production function.

Figure 2 shows the model for basic transaction tables, clearly indicating imports. For row items, both intermediate demand (X_{ij}) and final demand (F_i) are supplies including imports, and columns and rows (production) offset each other because imports are indicated negative values.

Input coefficients include imports. This implies that all repercussions derived from final demand do not necessarily induce domestic production; some effects may induce imports. In other words, for accurate determination of domestic production inducements, import inducements must be deducted. Thus it is necessary to provide a calculation method for inverse matrix coefficients that accounts for import inputs.

The equation from the IO model in figure 2 can be written as:

$$AX + F - M = X \quad (7)$$

Dividing final demand (F) into domestic final demand (Y) and export (E) gives the following equation:

$$F = Y + E$$

This is substituted into (7) above. The supply-demand balance equation can be expressed as follows:

$$AX + Y + E - M = X \quad (8)$$

Where M_i is the import value of sector i, import coefficients by row can be defined as follows:

$$m_i = \frac{M_i}{\sum_j a_{ij} X_j + Y_i}$$

Intermediate transactions Intermediate demand/intermediate input I	Final demand II	Import	Total output
Primary input/value added III			
Total input			

Figure 2. IO table (model $(I - (I - \hat{M})A)^{-1}$).

Source: Adopted from Leontief (1986).

In other words, "m_i" represents the ratio of imports in product "i" within total domestic demands, or ratios of dependence on imports; while $(1 - m_i)$ represents self-sufficiency ratios.

When (8) is represented for row "i", then:

$$\sum_j a_{ij}X_j + Y_i + E_i - M_i = X_i \quad (9)$$

From the definition of import coefficients and (9) we have the equation as follows:

$$X_i - (1 - m_i)\sum_j a_{ij}X_j = (1 - m_i)Y_i + E_i \quad (10)$$

The diagonal matrix ($\widehat{M}$) can be assumed to have an import coefficient (m_i) as the diagonal element and zero as the non-diagonal element.

$$\widehat{M} = \begin{bmatrix} m_1 & \dots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \dots & m_n \end{bmatrix}$$

From (7) above, the following equation can be obtained:

$$(I - (I - \widehat{M})A)X = (I - \widehat{M})Y + E \quad (11)$$

Then:

$$X = (I - (I - \widehat{M})A)^{-1}(I - \widehat{M})Y + E \quad (12)$$

Here, $(I - \widehat{M})A$ indicates the input ratio of domestic products when the import input ratio is assumed to be constant in all sectors, whether they are for intermediate demand or final demand. $(I - \widehat{M})y$ indicates domestic final demand for domestic products under the same assumption. In the actual economy, input ratios of domestic and imported products may generally differ from sector to sector. Thus, when this $(I - (I - \widehat{M})A)^{-1}$ type of inverse matrix coefficients is compared with the non-competitive IO table, significant differences may be observed at times in certain sectors. However, in case of lack of data, the inverse matrix coefficient tables based on this model $(I - (I - \widehat{M})A)^{-1}$ are commonly used as a means for handling the import effect when calculating the output multiplier and forward and backward linkages. This paper also uses this inverse matrix for the same reason.

To assess the impact of ICT on other sectors and the entire economy, the research uses the latest two IO tables. i.e. the 2007 and 2012 tables [24, 25], with 138 and 164 sectors respectively. A comparison of the two tables helps to analyze the development of ICT impact on the Vietnamese economy over time.

The ICT industry is grouped and classified according to the OECD's ICT definition and the International Standard of Industrial Classification (ISIC) [26, 27]). ICT is divided into three sectors: (1) ICT manufacturing produces electronic, computer and peripheral components, telecommunications devices, consumer electronics, instruments and appliances for measuring, checking, testing and navigating; (2) The ICT service sector includes the wholesaling of computers, electronics, components, software applications, software services, telecommunications services, postal services, information processing services, computers and telecommunications equipment repair services and other information services; and (3) ICT media and content sectors includes publishing, film, broadcasting, recording and other information activities.

For the purpose of analysis, sectors of the two IO tables are grouped into a portfolio of 27 broader sectors as shown in Table 1. The criteria used for sectorial consolidation include: (1) the list of 19 official sectors published by the General Statistics Office of Vietnam [24, 25]; (2) the international definition of the ICT sector, i.e. the OECD definition and ISIC [26, 27]; (3) the potential impact of ICT on each economic sector. Among these 27 sectors, there are 3 sectors (N1, N2, N3) of agriculture, 14 sectors (from N4 to N17) of manufacturing and 10 sectors (from N18 to N27) of services. In these 27 sectors, 3 sectors belong to ICT while 24 others are non-ICT sectors. See Appendix for more information.

Table 1. List of 27 grouped sectors of the Vietnamese economy

Sector	Description	Sector	Description
N1	Agriculture	N15	Other manufacturing and processing products
N2	Forestry	N16	Electricity and water
N3	Fishing	N17	Construction
N4	Metal ore and mineral products	N18	Wholesale and retail trade
N5	Processed foods	N19	Transportation services
N6	Drinks and cigarettes	N20	ICT media and content
N7	Textiles and leather products	N21	ICT services
N8	Wood and paper products	N22	Finance and Accounting services
N9	Chemical, petroleum, coal, rubber, plastic products	N23	Services of science, business, employment
N10	Non-metallic mineral products	N24	Public services
N11	Basic metals and other metal products	N25	Education services
N12	ICT manufacturing	N26	Health care services
N13	Machinery, equipment, utensils and their accessories	N27	Entertainment services and other services
N14	Transport equipment		

Source: Authors created from original sectors of IO tables 2007, 2012.

4. Results and discussion

4.1. ICT input and output structure of Vietnamese ICT sectors

In 2007, the whole of the ICT sectors reached the value added of USD 2,138 million, accounting for 3.16% of Vietnam's total value added. In 2012, the number was USD 6,021 million, accounting for 4.26% of the total value added of the entire economy. Compared to some countries in the region, Vietnam's ICT sectors accounted for a relatively small share of the economy. In 2005, ICT manufacturing and services (excluding ICT media and content) of Malaysia accounted for 12% of its GDP, Thailand 11% and Indonesia 4%. Between the two, the proportion of ICT manufacturing of these countries was much higher than that of ICT services. The origin of this margin is that countries such as Malaysia and Thailand had a policy to develop manufacturing of electronics, computers and consumer electronics for export. Exports took 75.6% and 94.3% of Malaysia and Thailand's total ICT sector's output, respectively [15]. As a result, the impact of ICT on other economic sectors in these two economies might not be as large as it is deemed to be based on the high proportion of ICT in the economy.

The input structure of ICT sectors is shown in Table 2. ICT manufacturing had a relatively higher percentage of intermediate input than the other two ICT sectors. The intermediate input of ICT manufacturing accounted for 87.96% of total input in 2007 which decreased to 79.50% in 2012. These figures suggest that the ICT manufacturing significantly affects many of the sectors which provide it input and the contribution of ICT manufacturing to the economy is more through stimulating other sectors rather than creating added value to the economy. The downward trend of intermediate input percentage from 2007 to 2012 of this sector suggests that it was requiring less input for production, which can be a sign of a higher level of the sector's technology.

ICT services and the ICT media and content sectors' intermediate input percentages were lower than that of ICT manufacturing; at 64.43% and 60.08% in 2012, respectively.

These numbers are consistent with the characteristics of service sectors which tend to use more direct human capital than manufacturing sectors. Compared to the numbers of 2007, the intermediate input percentages in 2012 of both these two ICT sectors were higher. The rationale behind this increase is that they used more machinery capital and less direct human capital for their production, which is also a good sign of the development of these two.

The composition of ICT output demand is shown in Table 3. ICT manufacturing output was mainly consumed as intermediary input. In 2012, the intermediate demand percentage of the ICT manufacturing was 67.44%. The sector also moved from a net import position in 2007 to net export in 2012, with net export accounting for 25.76% of total output. The ICT service sector divided its output evenly for intermediate demand and final demand. By contrast, the ICT media and content sector was primarily catering to the final demand which accounted for 89.42% of the total sector's output in 2012, leaving 35.81% for intermediate consumption demand. This sector was also a big net importer for domestic consumption. Data on the output demand structure suggests that the impact of ICT manufacturing on other economic sectors as an input provider would be the greatest, followed by the ICT service and ICT media and content sectors. The upward trend of intermediate demand proportions of all ICT sectors implies their developing economic impact through time.

More details on the impact of the ICT industry's final demand and on the economy's gross value added (GVA) in 2007 and 2012 are shown in Table 4. Among the components of the final demand, the share of ICT exports in GVA was the highest, reaching 2.25% in 2012. This figure was significantly higher than that in 2007 which indicated the transition to the export orientation of ICT sector of Vietnam. For domestic consumption, household consumption played a more important role than government consumption and capital formation of the industry. In 2012, household consumption contributed 1.46% of the gross added value of the economy. Consumption by the government only added 0.26% of the gross value added, but was considered as the stimulus for the development of Vietnam's ICT. The total contribution of the final demand of ICT sectors to GVA was 4.29%.

Comparing the contribution structure of the all ICT sectors to the gross value added of the economy with that of the total 27 economic sectors, a similar pattern can be noted. Demand for exports played the highest role, followed by household demand, asset formation and government demand. The contribution of the ICT sector' final demand was quite small compared to the total 27 sectors of the economy. In 2012, exports and household consumption ICT sectors contributed 2.25% and 1.46% to GVA, while these figures for 27 economic sectors were 41.75% and 38.27%, respectively.

4.2. ICT expenditure of economic sectors

The ICT expenditure percentage of economic sectors of the Vietnamese economy generally went up from 2007 to 2012. This was in line with the sector's growth and its increasing pervasiveness in the economy. However, the ICT input to total input ratios were basically low all over the economy. An average sector in the Vietnamese economy spent only 6.07% of all its input spending on ICT in 2007. The number increased to 8.81% in 2012. Thus, although the ICT usage in economic activities had increased, the level of usage was low so it was not yet possible to see the dramatic structural change impact of ICT in the Vietnamese economy as expected by theories.

Table 2. Input structure of Vietnamese ICT sectors (%)

Year	**2007**		**2012**	
Sector	Intermediate input	Value added	Intermediate input	Value added
ICT manufacturing	87.96	12.04	79.50	20.50
ICT services	48.25	51.75	64.43	35. 57
ICT media and content	57.28	42.72	60.08	39.92

Source: Authors calculated from IO tables 2007, 2012.

Table 3. Output demand structure of Vietnamese ICT sectors (%)

Year	**2007**			**2012**		
Sector	Intermediate demand	Final demand	Net export	Intermediate demand	Final demand	Net export
ICT manufacturing	54.57	55.18	-9.75	67.44	6.80	25.76
ICT services	49.65	48.09	2.26	44.92	53.42	1.66
ICT media and content	25.30	93.01	-18.30	35.81	89.42	-25.23

Source: Authors calculated from IO tables 2007, 2012.

Table 4. Impact of final demand on gross value added of the economy (%)

Year	**2007**					**2012**				
Final demand components	HHs. Consumption	Govt. Consumption	Capital formation	Export	GVA	HHs. Consumption	Govt. Consumption	Capital formation	Export	GVA
ICT manufacturing	0.33	0.02	0.45	0.09	0.88	0.30	0.03	0.24	1.94	2.50
ICT services	1.34	0.10	0.13	0.39	1.96	0.13	0.06	0.02	0.07	0.27
ICT media and content	0.19	0.11	0.00	0.03	0.32	1.04	0.18	0.05	0.24	1.51
ICT sectors	1.86	0.22	0.58	0.50	3.16	1.46	0.26	0.31	2.25	4.29
Impact of final demand components to GVA	42.09	5.15	13.76	39.00	100	38.27	4.97	15.01	41.75	100.00

Source: Authors calculated from IO tables 2007, 2012.

Table 5 presents the sectors with ICT expenditure more than 5% of total input spending. Data from the table shows that the ICT sectors themselves were the largest consumers of their products and services. In 2012, the ICT manufacturing expenditure on its own product accounted for 69.47% of its total input spending. The numbers for ICT services and ICT media and content were 40.47 and 27.96, respectively. In contrast, the consumption part of an ICT sector on other ICT sectors was generally low. In 2012, ICT manufacturing spent 0,16% of its total expenditure on ICT services and 0,05% on ICT media and content. Thus, the degree of interdependence of ICT sectors was relatively loose which might weaken the ICT development and total impact. The machinery, equipment, appliances and accessories sector used a large percentage of products from ICT manufacturing, while some trade and service sectors, such as wholesale and retail trade,

services of science, public services, and education services consumed a large percentage of products from both the ICT manufacturing and ICT service sectors. These were considered to be knowledge-intensive sectors in the economy, which were also the first sectors to experience many structure changes due to the impact of ICT (Table 5).

4.3. Output multiplier, backward and forward linkages of Vietnamese ICT sectors

Table 6 and 7 present output multipliers, backward linkages and forward linkages of ICT sectors calculated from competitive and non-competitive IO tables, respectively.

The output multiplier, backward linkage, and forward linkage values from the non-competitive IO tables in 2007 and 2012 tended to show clear trends compared to those values obtained from the competitive IO tables. From 2007 to 2012, the three values of ICT service and ICT media and content increased while those of ICT manufacturing decreased. Meanwhile, the upward /downward trend of output multiplier, backward linkage, and forward linkage values obtained from competing IO tables is unclear for all three ICT sectors. Besides, the resulting multipliers using non-competitive tables are comparatively much lower than those calculated based on the competitive type tables. These are due to the fact that developing economies such as Vietnam are highly dependent on imports. The imports per total value added ratio are high, at 97.5% in 2007 and 80.0% in 2012. These facts reassure that the analysis based on non-competitive IO tables are more precise than competitive IO on the interdisciplinary relationship of the economy as well as on the impact of ICT on the economy and other sectors. However, a comparison of the data in the two tables gives more insights about the import effect in the dispersion and sensitivity of ICT sectors in the economy.

The results from the non-competitive IO tables show the increasing impact of ICT services and ICT media and content sectors on the economy during 2007-2012. The ICT service sector's output multiplier grew from 1.66 to 1.95 and that of the ICT media and content sector grew from 1.82 to 1.92. This result reflects the fact that these two sectors were increasingly important to the economy. The economy, as well as other economic sectors, increasingly used ICT services and ICT media and content, and vice versa, the development of these sectors had a positive impact on the economy and other sectors.

Table 5. ICT expenditure percentage in some high ICT-input sectors (%)

Year	**2007**				**2012**			
ICT expenditure percentage / Sector	ICT manufac-turing	ICT services	ICT media and content	Whole ICT sectors	ICT manufac-turing	ICT services	ICT media and content	Whole ICT sectors
ICT manufacturing	44.96	0.34	0.00	45.30	69.47	0.16	0.05	69.67
Machinery, equipment, utensils and their accessories	7.11	0.26	0.00	7.38	7.21	0.12	0.02	7.35
Electricity and water	0.46	0.49	0.01	0.96	4.79	0.22	0.05	5.06
Wholesale and retail trade	0.85	5.49	0.23	6.57	0.92	3.26	1.36	5.54
ICT media and content	1.59	3.56	10.87	16.01	1.16	2.41	27.96	31.52
ICT services	8.09	18.56	0.23	26.88	27.42	40.47	1.12	69.02
Services of science, business, employment	1.91	4.14	1.44	7.50	0.96	3.05	10.80	14.81
Public services	5.10	6.86	2.03	13.99	1.51	4.89	3.58	9.98
Education services	3.86	3.73	1.00	8.59	1.44	2.86	3.13	7.43
Average of all 27 sectors	3.05	2.36	0.66	6.07	4.37	2.42	2.02	8.81

Source: Authors calculated from IO tables 2007, 2012.

In other words, ICT services and ICT media and content had an increasingly stronger link in production with other economic sectors leading to the pull-effect (using input products of other industries) and the push-effect (supplying products to other sectors) being strongly increased.

Also from the analysis of non-competitive IO tables, the output multiplier, backward linkage, and forward linkage values of ICT manufacturing declined. There might be two reasons for this: (i) the size of the Vietnamese economy increased rapidly, from $98.3 billion in 2007 to $ 155.6 billion in 2012 making the relative impact of ICT sectors decrease and (ii) the price of ICT manufacturing products tended to decrease due to technological advances, leading to a decrease in the cost of ICT manufacturing products in the cost structure of the economic sectors, which in turn resulted in the weaker linkage of ICT manufacturing to other sectors of the economy. Although the output multiplier value of the ICT manufacturing sector fell, the output multiplier was still at a relatively high level, suggesting that the production of the sector's products retained a strong impact on the economy.

Comparison of the output multipliers of ICT manufacturing between the competitive and non-competitive IO tables in both 2007 and 2012 shows significant differences. In 2007, the output multipliers of ICT manufacturing from the competitive and non-competitive IO table were 3.84 and 2.16; and in 2012 these figures were 4.13 and 1.89, respectively. The reason might relate to the fact that from 2009, Samsung Group of Korea started to promote investment in Vietnam to produce ICT products and the first factory was put into operation from April 2009 in Bac Ninh. However, the company imported most of the components to produce electronic products, leading to an increase in imports of ICT manufacturing from USD 706 million in 2007 to USD 12,528 million in 2012. Thus, the impact of domestic production of ICT manufacturing was significantly lower than that of the sector with imports included.

Table 6. ICT output multiplier, backward linkage, forward linkage from competitive IO tables

Year	**2007**			**2012**		
Sector	ICT manufacturing	ICT services	ICT media and content	ICT manufacturing	ICT services	ICT media and content
Output multiplier (output multiplier)	3.84	2.16	2.56	4.13	3.21	2.86
Backward linkage (backward linkage)	1.43	0.81	0.96	1.35	1.05	0.93
Forward linkage (forward linkage)	0.81	0.58	0.42	1.23	0.55	0.46

Source: Authors calculated from IO tables 2007, 2012.

Table 7. ICT output multiplier, backward linkage, forward linkage- from non-competitive IO tables

Year	**2007**			**2012**		
Sector	ICT manufacturing	ICT services	ICT media and content	ICT manufacturing	ICT services	ICT media and content
Output multiplier	2.16	1.66	1.82	1.89	1.95	1.92
Backward linkage	1.24	0.95	1.04	1.05	1.08	1.07
Forward linkage	1.06	0.81	0.62	1.03	0.86	0.70

Source: Authors calculated from IO tables 2007, 2012.

Figure 3 compares the output multipliers of ICT sectors and those of other non-ICT sectors. Throughout 27 sectors of the Vietnamese economy, ICT sectors have output multipliers at just above the average. Thus, the dispersion impact of ICT sectors was not much higher than non-ICT sectors. Compared to the ICT manufacturing industry's output multipliers in some other regional countries such as Malaysia at 1.64, Thailand at 1.38 and Indonesia at 1.68 (Irawan, 2013 [15]), it can be seen that the output multiplying impact of Vietnamese ICT manufacturing was a little bit higher. This might be attributed to the fact that the Vietnamese ICT served significantly for the domestic demand while the Malaysia and Thailand's ICT sector mainly served for export.

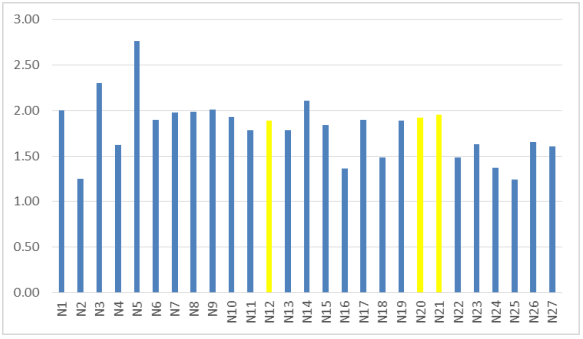

Figure 3.Output multipliers of sectors in the Vietnamese economy.
Source: Authors calculated from IO tables 2007, 2012.

All three ICT sectors had stronger backward linkages than forward linkages. This is in line with the analysis of the output and input structure of the sectors above, in which all sectors consumed a high percentage of intermediate input from the economy while supplying a relatively low percentage of intermediate demand.

A comparison of backward and forward linkages of ICT sectors with other economic sectors of the Vietnamese economy shows that the backward linkage of the ICT industry was stronger than the average of all sectors of the economy, but forward linkages of the ICT industry is weaker than the average of all sectors (Figure 4). Thus ICT's output multiplying effect was based more on backward linkage than forward linkage. In other words, Vietnam's ICT has been the driving force of economic growth, but the role as an input provider for other sectors to create structural changes and business efficiency across sectors as projected by above mentioned GPT model and technological paradigm theory was blurred.

Table 8 presents the sectors that received the strongest ICT output multiplying impacts. The general characteristics of these sectors are either technology-intensive or service-oriented. Table 8 shows that the ICT sector received the largest output multiplying impact from itself and other ICT sectors. The impact of ICT on the output of other sectors tended to increase in two phases.

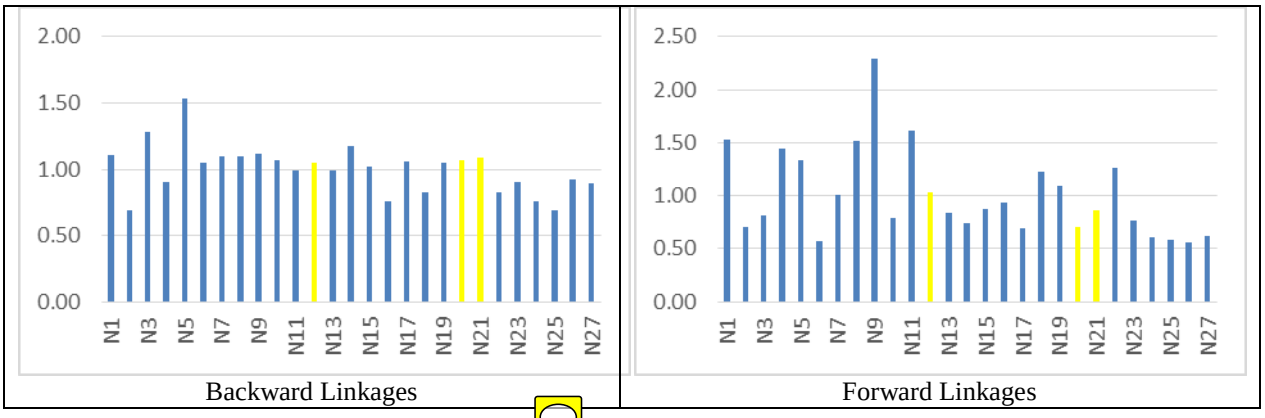

Figure 4. Backward and Forward linkages of Vietnamese economic sectors
Source: Authors calculated from IO tables 2007, 2012.

Table 8. ICT output multiplying impact on other economic sectors

Year	**2007**			**2012**		
Sector	ICT manufacturing	ICT services	ICT media and content	ICT manufacturing	ICT services	ICT media and content
Chemical, petroleum, coal, rubber, plastic products	0.171	0.084	0.084	0.067	0.052	0.061
Basic metals and other metal products	0.043	0.006	0.006	0.079	0.045	0.017
ICT manufacturing	1.533	0.002	0.002	1.444	0.213	0.017
Machinery, equipment, utensils and their accessories	0.033	0.004	0.004	0.030	0.016	0.007
Other manufacturing and processing products	0.021	0.006	0.006	0.023	0.015	0.015
Electricity and water	0.028	0.020	0.020	0.012	0.029	0.026
Wholesale and retail trade	0.177	0.092	0.092	0.076	0.045	0.048
Transportation services	0.050	0.028	0.028	0.034	0.034	0.055
ICT media and content	0.000	0.000	0.000	0.001	0.009	1.144
ICT services	0.010	0.006	0.006	0.005	1.339	0.025
Finance and Accounting services	0.012	0.008	0.008	0.021	0.042	0.076
Services of science, business, employment	0.011	0.004	0.004	0.007	0.015	0.018

Source: Authors calculated from IO tables 2007, 2012.

5. Conclusion

The research results show that although ICT has been a sector which is a focus of Vietnamese government's economic strategy, ICT was still only a small part, in terms of the value added contribution, of the economy. The input and output structures of ICT sectors were not the same. ICT manufacturing used more intermediate input and served more for production of other sectors while ICT media and content used more primary input and served more for final consumption. The shifts in the ICT sectors' input and output structures from 2007 to 2012, on the one hand asserted technological development of ICT sectors, and

on the other hand projected larger impact of ICT as an important input of the economy through time.

Research also indicates that the spending percentage of ICT products and services in an average sector of the Vietnamese economy was generally low. There appeared some knowledge-intensive sectors which were the pioneers in adopting ICT and expected to witness changes in their production first. The results imply the first phase of the ICT technological paradigm described in Perez (2004) [3].

Regarding the impact on the output of other sectors, the research results reveal that ICT services and ICT media and content had an increasingly stronger link in production with other economic sectors leading to a strongly increased pull-push effect. In contrast, the dispersion effect of the ICT manufacturing sector fell; despite this fact, ICT manufacturing retained a strong impact on the economy. Results also reveal that the impact of the domestic production of this sector was especially lower than import-included production due to the high level of imports for production. The ICT sectors' backward linkages were stronger than forward linkages, i.e. the ICT sectors generated more impact on sectors which provided it input rather than on sectors that used its products and services. The total output multiplying effect of the ICT was at the average of the 27 sectors; the impact of ICT was not much higher than that of the other non-ICT sectors in the Vietnamese economy. Compared to the ICT sectors of some countries in the region such as Malaysia and Thailand, Vietnam's ICT was smaller; however, its output multiplying effect was larger.

Perez (2004) and Freeman (2005) argue that the formation and development of a technology paradigm is a process in which technological, economic and institutional factors interact [3, 4]. Bresnahan and Trajtenberg (1992) claim that a decentralized economy will have difficulty in fully exploiting the growth opportunities of GPT's and ICT requires large adjustments from the economy to realize its impact [10]. Despite a marked shift from 2007 to 2012 showing higher impact, the current impact of ICT in the Vietnamese economy is deemed to be still small. This implies that if the ICT-based economy is to be promoted, the Vietnamese government will need more policies to promote the development of the ICT industry as well as the application of ICT in economic activities in the whole country.

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APPENDIX

Sector compounding from original IO tables

Sector	Description	IO 2007 sector number	IO 2012 sector number
N1	Agriculture	12	1- 21
N2	Forestry	13, 14	22-25
N3	Fishing	15, 16	26, 27
N4	Metal ore and mineral products	17-22	28-34
N5	Processed foods	23-34	35-46
N6	Drinks and cigarettes	35-38	47-50
N7	Textiles and leather products	39-43	51-55
N8	Wood and paper products	44, 45, 46	56-58
N9	Chemical, petroleum, coal, rubber, plastic products	47-56	59-69
N10	Non-metallic mineral products	57, 58, 59	70-73
N11	Basic metals and other metal products	60, 61	74, 75, 76
N12	ICT manufacturing	62-65, 70	77, 78
N13	Machinery, equipment, utensils and their accessories	66-69, 71, 72, 73	79- 88
N14	Transport equipment	74-78	89-93
N15	Other manufacturing and	79-82	94-98

Sector	Description	IO 2007 sector number	IO 2012 sector number
	processing products		
N16	Electricity and water	83-87	99-105
N17	Construction	88, 89, 90	106-111
N18	Wholesale and retail trade	91, 92	114
N19	Transportation services	93-101, 103, 104	112, 113, 115-123, 125, 126
N20	ICT media and content	105, 106, 107	127, 128, 129, 132
N21	ICT services	102, 108, 109, 137	124, 130, 131, 162
N22	Finance and Accounting services	110-115	133- 138
N23	Services of science, business, employment	116, 117, 119, 121-127	139-150
N24	Public services	118, 120, 128	141, 143, 151
N25	Education services	129, 130	152, 153
N26	Health care services	131, 132	154-156
N27	Entertainment services and other services	133-136, 138	157-164