

Information Technology in Vietnam Economy Based In Input - Output Analysis

Trinh Bui¹, Phong Nguyen Viet², Gia Bui³, Trung Quang Dam⁴

¹(FSB, FPT University, Vietnam,

²(Vietnam National Statistic Office,

³(University of Economics - Vietnam National University, Hanoi,

⁴(International School - Vietnam National University, Hanoi,

*Corresponding Author: Trung Quang Dam⁴

ABSTRACT : Recently, the term Digital Economy has been mentioned by the media and even economists as a trendy word. This study focuses on assessing the impact of the information technology (IT) industry group including IT manufacturing and IT services on a number of other industries in the economy. This study examines the relationship of the Information technology (IT) with the Vietnamese economy based on input - output analysis. The input - output table was updated by the research team for the year of 2022 with 20 industries. The research results show that the overall spillover effects of the IT manufacturing and IT service industries are both low. The final products of IT sector induced impacts little to domestic production but strongly to imports. This means that Vietnam's IT manufacturing mainly spills over to imports. Domestic supporting products for IT production are relatively weak. The research results suggest some important macro policy implications to focus on developing the IT industry and some industries with good spillover effects to contribute to promoting Vietnam's economic growth in the future.

KEYWORDS - analysis, IT; multiplier effects, induced effects, spillover effects; input output; Vietnam's economy

I. INTRODUCTION

Since Leontief's Input-Output System (IOS) was born (1936, 1941) it has been developed and expanded in many directions by many different researchers. In the development of more general economy-wide models, an initial addition to standard input-output systems called social accounting matrices (SAMs) most closely associated with Stone, Pyatt, and Round, 1985; Hewings and Madden, 1995. The original I.O table was also developed into an interregional I.O table by Isard (1951, 1960), a multiregional input-output (MRIO) model by Chenery (1954) and Moses (1955), Miller, Blair (1985) and Hirsch (1959); Parallel to the social accounting matrix system (SAM) of Stone (1961) and Pyatt and Rose (1977) is the demographic - economic model developed by Miyazawa (1976) and Madden, Batey. (1983), the demographic-economic model was developed by Miyazawa to analyze the income distribution structure according to endogenous consumption expenditure according to Leontief system standards. This type of model is later referred to as IO type II.

In Vietnam, the I.O table has long been called the inter-industry balance table (Inter-industry balance table) and studies the influence of an industry or group of industries on the economy based on inter-industry relations of the I.O table has been done in a number of studies such as "Forestry sector and sustainable development policies in Vietnam: Analysis from input - output model" (2019), "perennial trees in the Vietnam's economy - Perennial Plants in Vietnam's Economy" (2022), "Measuring digital value in the economy: The case of Vietnam" (2022) ...In these studies the concept of interdisciplinary analysis is compatible with Miyazawa, Sonis, and Hewing's notion of interregional analysis ; The Hawaii Department of Business, Economic Development and Tourism (DBEDT) applied this method to inter - county input - output research in 2007, 2012, 2017.

This research is based on Vietnam's I.O table, compiled for 20 industries in 2022 including the IT industry group and the remaining industries as below:

Table 1. 20 industries of the I.O table in the research model

No.	Name of industries
1	IT
2	Other digital
3	Agriculture, forestry, fisheries
4	Mining sector

5	Processing and manufacturing industry (excluding digital production in sector 2)
6	The industry produces and distributes electricity, gas, hot water, steam and air conditioning
7	Water supply, waste and wastewater management and treatment activities
8	Construction
9	Car, motorbike, motorbike and motor vehicle sales and repair services (not using digital platforms - traditional industries)
10	Wholesale (non-digital - traditional industries)
11	Retail (non-digital - traditional industries)
12	Transportation and warehousing (not using digital platforms - traditional industries)
13	Accommodation services (not using digital platforms - traditional industries)
14	Catering services (not using digital platforms - traditional industries)
15	Real estate business activities
16	Professional, scientific and technological activities; Administrative operations and support services; Activities of the Communist Party and other organizations
17	Education and training
18	Health and social assistance activities
19	Arts, entertainment and recreation
20	Other service activities

II. METHODOLOGY

The basic relationship in I.O analysis has the form:

$$X = (I - A)^{-1} \cdot Y \tag{1}$$

Where X is the output vector, I is the unit matrix, A is the direct input coefficient matrix and Y is the final use vector.

In this study, matrix A is divided into sub-matrices as follows:

$$A = \begin{bmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{bmatrix} \tag{2}$$

A₁₁ shows IT industry group that uses its own inputs as intermediate input; dimension of A₁₁ is (1 x 1)

A₁₂ shows other industries (19 remain industries) in the economy that use IT sector products as intermediate input; dimension of A₁₂ is (1 x 19)

A₂₁ shows that the IT industry uses products from other industries as intermediate inputs; dimension of A₂₁ is (19 x 1)

A₂₂ shows other industries in the economy that use its own products as intermediate inputs; dimension of A₂₂ is (19 x 19)

The output vector includes the output of IT industry group X₁ and the output of other industries in the economy X₂; in this case, dimension of X₁ is (1 x 1) and X₂ is (19 x 1), so dimension of X is (20 x 1).

$$X = \begin{bmatrix} X_1 \\ X_2 \end{bmatrix} \tag{3}$$

The final use vector includes the final products of IT sector Y₁ and the final products of other industries Y₂:

$$Y = \begin{bmatrix} Y_1 \\ Y_2 \end{bmatrix} \tag{4}$$

Put

$$B = (I - A)^{-1} = \begin{bmatrix} B_{11} & B_{12} \\ B_{21} & B_{22} \end{bmatrix} \quad (5)$$

From (1), (2), (3), (4) and (5) we can analyze the output of the IT industry (X_1) and the output of other industries (X_2) in the economy as follows:

$$X_1 = B_{11} \cdot Y_1 + B_{12} \cdot Y_2 \quad (6)$$

$$X_2 = B_{21} \cdot Y_1 + B_{22} \cdot Y_2 \quad (7)$$

Furthermore, in order to understanding the diffusion to be according to Miyazawa, Sonis and Hewings; the Leontief B matrix is developed as follow:

$$B = \begin{bmatrix} B_{11} & B_{12} \\ B_{21} & B_{22} \end{bmatrix} = \begin{bmatrix} B_{11} & B_{11} \cdot A_{12} \cdot B_2 \\ B_{22} \cdot A_{21} \cdot B_2 & B_{22} \end{bmatrix} \quad (8)$$

Therefore, the Leontief relation is seen in sub - matrix form as follows:

$$\begin{bmatrix} X_1 \\ X_2 \end{bmatrix} = \begin{bmatrix} B_{11} & B_{11} \cdot A_{12} \cdot B_2 \\ B_{22} \cdot A_{21} \cdot B_2 & B_{22} \end{bmatrix} * \begin{bmatrix} Y_1 \\ Y_2 \end{bmatrix} \quad (9)$$

Where:

$$B_1 = (I - A_{11})^{-1} \quad (10)$$

$$B_2 = (I - A_{22})^{-1} \quad (11)$$

B_{11} is called the enlarge Leontief inverse, which is mixed between multiplier effects (B_1) and induced effects by production of other industries when intermediate inputs of IT sector used intermediate input of other industries (A_{21}) lead to stimulated output of other industries ($B_2 \cdot A_{21}$); thereby stimulating the production of the IT industry; We define it as inter - industry feedback effects or feedback loop multipliers: $(I - B_1 A_{12} B_2 A_{21})^{-1}$. This concept was cited in the report on inter - county input - output analysis of report Hawaii Department of Business, Economic Development and Tourism (DBEDT) (2016) "The 2017 Hawaii Inter-County Input-Output Study" Research and Economics Analysis Division Department of Business, Economic Development and Tourism STATE OF HAWAII.

So, output multipliers of IT include:

+ Multiplier effects were excited by a unit IT's final products: $(I - A_{11})^{-1}$ includes:

- Initial effects: $I (1)$: The beginning for production (For example, an enterprise has enough production capacity but has not yet produced)

- Direct effects: A_{11} : Direct input coefficient of IT that used product of IT for production a unit output of IT

- Indirect effects: $(I - A_{11})^{-1} - I - A_{11}$: Requirement for its own product when producing round 1

+ Induced effects (or inter-industry feedback effects) was excited by production of other industries when output of these industries increased by input of IT used them: $B_{11} \cdot (I - A_{11})^{-1}$

+ Spillover effects on output to other industries by the final product of the IT when used products of industries as intermediate input: $B_{21} = B_{22} \cdot A_{21} \cdot B_1$

The same goes for final products of other industries.

Let h, l be the vector of coefficients of income and labor compared to the output let h^* and l^* be the diagonal matrices of vectors h and l , thus: H and L are the vectors of income and labor; where H_1 is the income of the IT sector industry and H_2 is the income of other industries; L_1 is the IT's labor and L_2 is the labor of other industries

Multiplying the two sides of relation (8) by h^* and l^* we have:

$$\begin{bmatrix} H_1 \\ H_2 \end{bmatrix} = \begin{bmatrix} h_1 & 0 \\ 0 & h_2 \end{bmatrix} * \begin{bmatrix} B_{11} & B_{11} \cdot A_{12} \cdot B_2 \\ B_{22} \cdot A_{21} \cdot B_2 & B_{22} \end{bmatrix} \begin{bmatrix} Y_1 \\ Y_2 \end{bmatrix} \quad (12)$$

$$\begin{bmatrix} L_1 \\ L_2 \end{bmatrix} = \begin{bmatrix} l_1 & 0 \\ 0 & l_2 \end{bmatrix} * \begin{bmatrix} B_{11} & B_{11} \cdot A_{12} \cdot B_2 \\ B_{22} \cdot A_{21} \cdot B_2 & B_{22} \end{bmatrix} \begin{bmatrix} Y_1 \\ Y_2 \end{bmatrix} \quad (13)$$

Explicit relationship (10) shows:

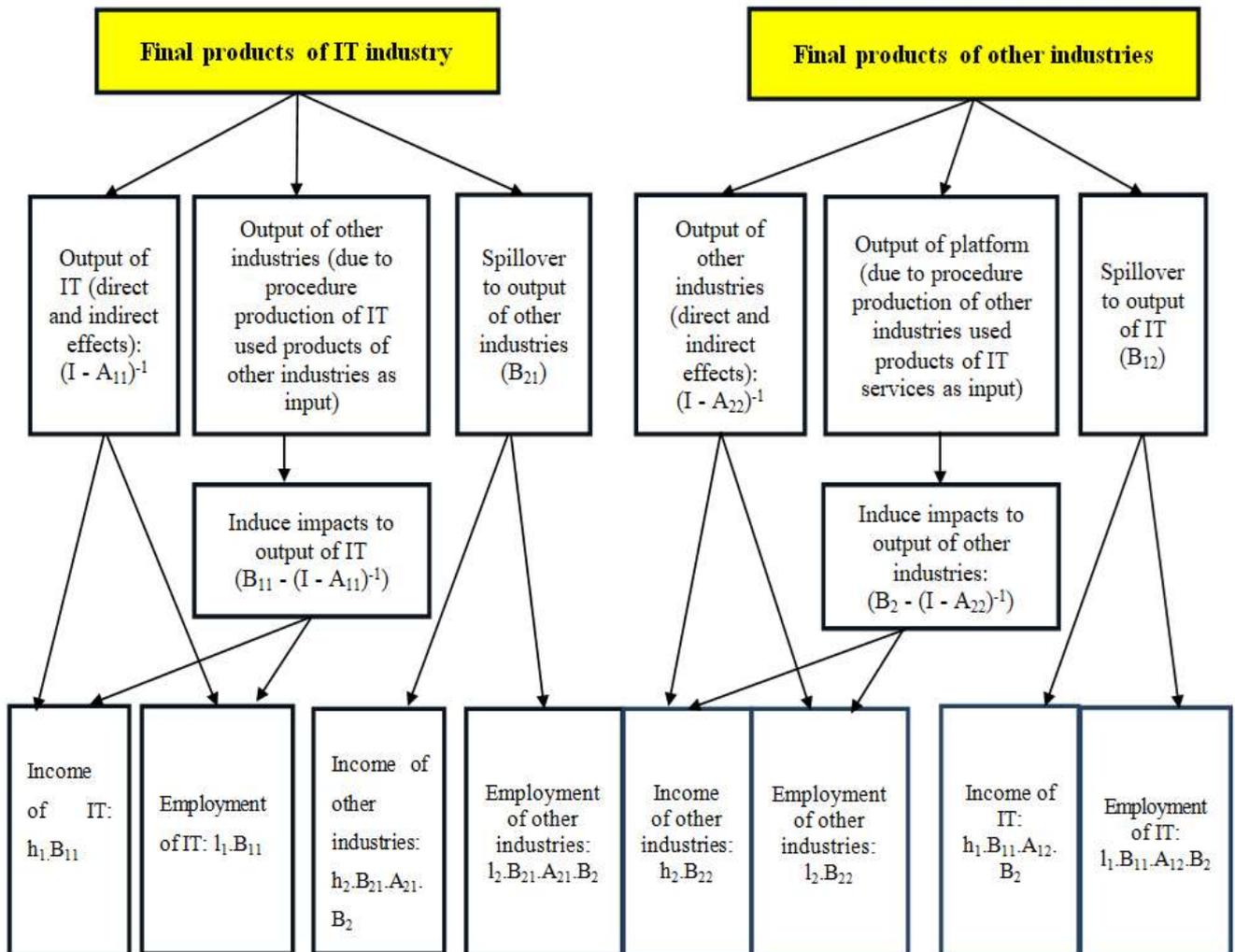
- + The stimulation of a unit of IT industry final product to IT industry income is: $h_1 \cdot B_{11}$
- + The final products of the IT industry stimulate to the income of other industries $h_2 \cdot B_{21} \cdot A_{21} \cdot B_2$
- + Final products of other industries stimulate the income of the IT industry: $h_1 \cdot B_{11} \cdot A_{12} \cdot B_2$
- + Other industries' final products stimulate their own income: $h_2 \cdot B_{22}$

Explicit relationship (11) shows:

- + The stimulation of a unit of IT industry final product to IT industry labor is: $l_1 \cdot B_{11}$
- + The final products of the IT industry stimulate to the labor of other industries $l_2 \cdot B_{21} \cdot A_{21} \cdot B_2$
- + Final products of other industries stimulate the labor of the IT industry: $l_1 \cdot B_{11} \cdot A_{12} \cdot B_2$
- + Other industries' final products stimulate their own labor: $l_2 \cdot B_{22}$

These above relationships are intended to describe the final product of an industry that stimulate to production value (its own and that of other industries) and then stimulate to value added, income and labor (its own and other industries). These are shown in the following general diagram:

Diagram on effecting stimulated by final products of IT industry and other industries



III. CASE STUDIES

From the structure of the 2022 I.O table updated for 20 industries, it shows that on the supply side, the ratio of value added in gross input of the IT industry is higher than the ratio of the other industries in the

economy (55% compared to 28%); This partly reflects that the production efficiency of the IT industry is better than the overall production efficiency of the economy.

On the demand side, it shows that the final demand of the IT is higher than the intermediate demand of IT for production (60% and 40% respectively) (Table 2).

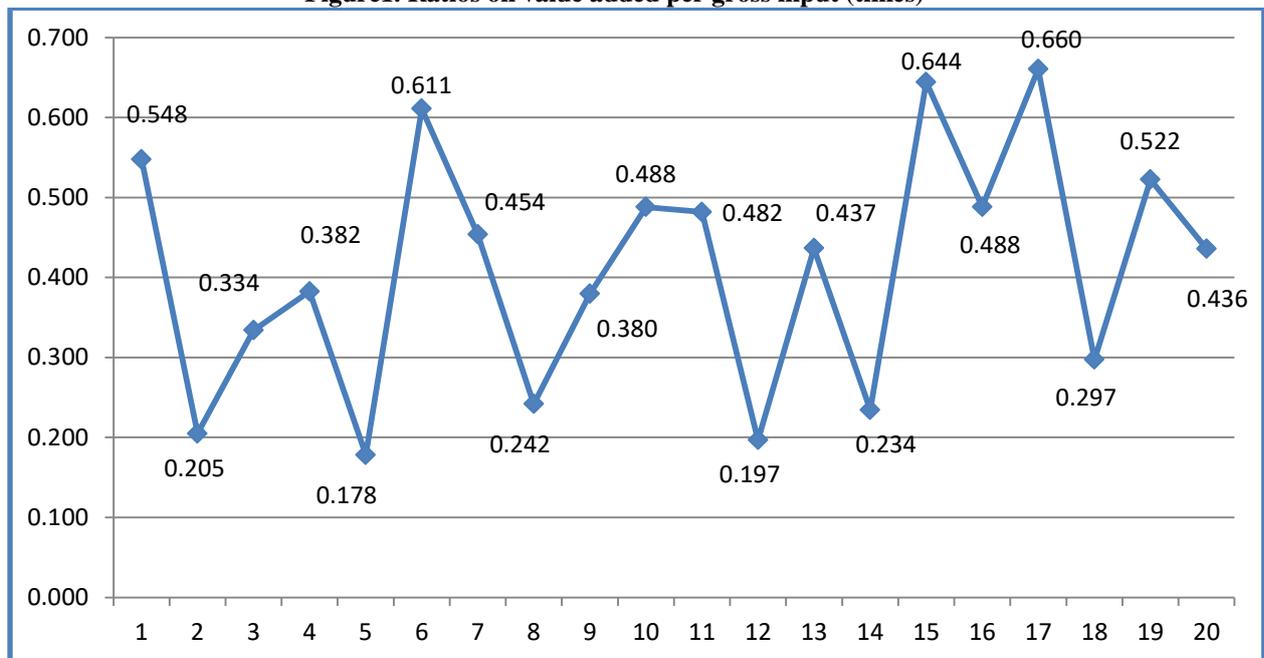
Table 2. Supply and demand Structure s of IT and national (%)

	Input structure			Demand structure		
	Intermediate input	Value added	Gross input	Intermediate demand	Final demand	Gross output
IT	45%	55%	100.0%	40%	60%	100.0%
Other industries	71%	29%	100.0%	72%	28%	100.0%

Source: Calculated from Vietnam's 2022 I.O table

More details, in Figure 1 show that the ratio of value added to gross input of the IT industry is one of the 4 industries with the highest ratio among the 20 industries surveyed in the model. Four industries have ratios on value added per gross input high Includes: IT (0.548), education and training (0.660); Real estate business activities (0.664); Electricity, gas, hot water, steam and air conditioning production and distribution industry (0.611).

Figure1. Ratios on value added per gross input (times)



Source: Calculated from Vietnam's 2022 I.O table

In Input - output analysis, the power of dispersion index is average of output multipliers. If call the output multiplier of industry j is OM_j so, the power of dispersion index of industry j is P_j . P_j is determined as follows:

$$P_j = n \cdot OM_j / \sum OM_j \quad (n = \text{number of industries} = 20)$$

And the sensitivity of dispersion index is average of input multipliers, if call the input multiplier of industry i is IM_i so the sensitivity of dispersion index of industry i is S_i , then S_i is determined as follows:

$$S_i = n \cdot IM_i / \sum IM_j \quad (n = \text{number of industries} = 20)$$

Industries with a power of dispersion index greater than 1 are industries that stimulated important to the economy.

Industries with a sensitivity of dispersion index greater than 1 are industries that are relatively necessary for the economy.

Table 3 shows that the final products of the IT industry in Vietnam stimulate the output of the economy lower than the general average (0.736 compared to 1); however, the sensitivity of dispersion of the IT industry is

higher than the general average (1,137 compared to 1). Note that the IT industry is with other digital economy industries (industry group 2), agriculture, forestry and fishery industry group (industry group 3) and manufacturing and processing industry (excluding digital production in industry 2 - industry group 5) are the industry groups with the highest sensitivity. Industry group 5 has very high sensitivity because almost every industry uses products from this industry group as input costs. Because the I-O table is compiled in competitive form (competitive - import type), it is also possible that these inputs are not entirely domestically produced products but are imported.

Table 3. Economic structure (times)

Sectors	Output multipliers	Power of dispersion	Input multipliers	Sensitivity of dispersion
1	2.339	0.736	3.615	1.137
2	4.305	1.355	4.966	1.563
3	3.526	1.110	6.835	2.151
4	3.355	1.056	2.772	0.872
5	4.181	1.315	24.150	7.599
6	2.420	0.761	1.852	0.583
7	3.023	0.951	1.216	0.382
8	4.049	1.274	1.393	0.438
9	3.255	1.024	1.094	0.344
10	2.673	0.841	1.934	0.609
11	2.695	0.848	1.570	0.494
12	4.168	1.311	2.044	0.643
13	2.983	0.939	1.093	0.344
14	3.873	1.219	1.197	0.377
15	2.214	0.697	1.704	0.536
16	2.772	0.872	1.868	0.588
17	2.157	0.679	1.060	0.334
18	3.858	1.214	1.014	0.319
19	2.611	0.822	1.149	0.361
20	3.105	0.977	1.036	0.326

Source: Calculated from Vietnam's 2022 I.O table

Table 4 shows that although the impact of the final products of the IT industry to the economy's output is lower than the general impact level (table 3), but the impact to the value added and income of the economy is higher than the level. Overall average (1.015 and 1.067 respectively).

An interesting thing is that the final products of the manufacturing industry (industry 5) strongly stimulate to the output of the economy (table 3) but spill over to value added and income for the economy is lower than the general average (0.980 and 0.987 respectively). That is one of the reasons why only stating the impact on output in many cases does not make much sense, especially for developing countries.

Regarding labor, it shows that one billion USD of final products of the IT industry creates 65.7 thousand workers in all industries. However, the labor stimulation of the IT industry is not high because workers in this industry must have good skills; sector 3 (agriculture, forestry and fisheries), sector 9 (Services for selling and repairing cars, motorbikes, motorbikes and motor vehicles (not using digital platforms - traditional sectors), sector 20 (other services) because they do not need much skilled labor, the spillover of final demand to labor is higher than the general average.

Table 4. Impact of a unit of final demand to value added, income and labor (times and thousand peoples)

Sectors	Value added multiplier	Power of dispersion on value added	Income multipliers	Power of dispersion on income	Labor multipliers (thousand peoples)	Power of dispersion on labor
1	0.961	1.015	0.615	1.067	65.667	0.497
2	0.867	0.916	0.499	0.865	97.117	0.734
3	0.946	1.000	0.624	1.082	159.109	1.203
4	0.949	1.003	0.538	0.932	66.016	0.499
5	0.928	0.980	0.569	0.987	115.383	0.873
6	0.966	1.021	0.370	0.642	42.887	0.324
7	0.945	0.998	0.582	1.009	103.796	0.785
8	0.936	0.989	0.631	1.094	149.877	1.133
9	0.942	0.995	0.650	1.127	174.955	1.323
10	0.968	1.023	0.617	1.070	171.286	1.295
11	0.968	1.023	0.616	1.068	121.762	0.921
12	0.943	0.996	0.586	1.016	130.334	0.986
13	0.958	1.012	0.575	0.997	272.415	2.060
14	0.946	1.000	0.606	1.051	150.133	1.135
15	0.956	1.010	0.354	0.614	51.322	0.388
16	0.955	1.009	0.687	1.191	104.875	0.793
17	0.973	1.028	0.653	1.132	131.705	0.996
18	0.945	0.998	0.647	1.122	133.356	1.009
19	0.931	0.983	0.437	0.757	88.065	0.666
20	0.947	1.001	0.678	1.176	314.535	2.379

Note: To study an industry in the economy, the exogenous variable (Y) is understood as final products; regarding to national research, final products, final demand or final use are the same.

Table 5 shows that one billion USD of the IT industry's final products stimulates its own output by USD 1.358 billion; Of which, directly stimulated from the final product is 1,329 billion USD and stimulated through the used of inputs to be products of other industries lead to stimulate production of other industries, which in turn stimulates output of IT industry (inter - industry feedback effects) is 0,029 billion USD. In addition, 1 billion USD of the final product of the IT industry not only stimulates its own output but also stimulates the output of other industries by 0,982 billion USD. The total impact of 1 billion USD of final products of the IT industry on the entire economy is 2,339 billion USD.

Table 5. Impact of a unit IT's final products (times)

1	Total impact of IT's final products to output of IT (2 + 6)	1.358	
2	Multiplier effects (3 + 4 + 5)	1.329	$(I - A_{11})^{-1}$: shows impact of a unit of IT 's final products to IT's output
3	Initial effects	1.000	The beginning for production
4	Direct effects	0.247	A_{11} : Direct input coefficient of IT that used product of IT for production a unit output of IT
5	Indirect effects	0.081	$(I - A_{11})^{-1} - I - A_{11}$: Requirement for its own product when producing round 1

6	Induced effects	0.029	B11-(I A11)-1: Output of other industries (due to procedure production of platform used products of other industries as input), these induced impact to output of IT – Inter – industry feedback effects
7	Spillover effects to output of other industry	0.982	B21: In equation (5); it shows a unit of IT's final products spillover to output of other industry
8	Total impacts (output multiplier: (1 + 7))	2.339	Output requirement of economy for a unit of IT's final products

Source: Calculated from Vietnam's 2022 I.O table

Table 6 aims to clarify the impact of the final products of the IT industry on other industries (the remaining 19 industries) of the economy. The industry that benefits the most when the final products of the IT industry group increase is industry group number 5 (Processing and manufacturing industry: 46.6%); followed by industry group number 2 (other digital economy: 21.2%); and industry group number 3 (Agriculture, forestry, fisheries: 10.4%)...

Table 6. The final products of the IT spread to the output of industries in the Vietnamese economy (B21)- times

	Spillover effects (times)	Percentage of spillover
Total spillover effects	0.982	100.0%
2	0.208	21.2%
3	0.102	10.4%
4	0.029	2.9%
5	0.457	46.6%
6	0.022	2.2%
7	0.002	0.2%
8	0.007	0.7%
9	0.001	0.1%
10	0.022	2.3%
11	0.014	1.4%
12	0.025	2.6%
13	0.004	0.5%
14	0.009	1.0%
15	0.036	3.6%
16	0.038	3.9%
17	0.003	0.3%
18	0.000	0.0%
19	0.001	0.1%
20	0.001	0.1%

Source: Calculated from Vietnam's 2022 I.O table

Table 7 shows that the IT's output are not only created by the final products of the IT but also by the final products of other sectors in the economy. The result shows that 62,4% of IT industry output is made up of final products from other industries in the economy (because production of other industries uses IT industry products as input costs); This partly shows the quite high “digitalization” of the Vietnamese economy.

Table 7. Output of IT created by a unit final products of IT and final products of other industry (times, %)

	Final product of IT (Y ₁)	Final product of other industry (Y ₂)	Total (input multipliers)
Output of IT	1.358	2.257	3.614
Percentage contribute	37.6%	62.4%	100.0%

Source: Calculated from Vietnam's 2022 I.O table

The results in table 8 shows that:

+ *Effect on value added*: one billion USD of the IT's final product stimulates to the value added of the economy is 0,9607 billion USD, of which the stimulated to its own value added of 0,727 billion USD (accounting for 75,64% in the total impact) and stimulates the value added of other industries of 0,234 billion USD (accounting for 24,36% in the total impact).

+ *Effect on income*: it also shows that 1 billion USD of IT's final product stimulated to the income of the economy's workers is about 0,615 billion USD, of which the excited to the income of its own workers is about 0,481 USD (accounting for 78,24% in the total impacts) and excited on the income of workers in the remaining industries about 0,134 USD (accounting for 21,76% in the total impacts).

+ *Effect on labor*: one billion USD of IT's final product stimulated to labor of economy is about 65,7 thousand people, of which the stimulated to labor of IT is about 38,3 thousand people (accounting for 58,28% in the total impacts) and stimulated to the remaining industries about 27,4 thousand people (accounting for 41,72% in the total impacts). This result shows that the effect on labor of IT stimulated to other industries is the biggest effect (better than effect on value added and income). The more platform industry developed, the more workers are created.

Table 8. Impact of a unit IT's products to value added, income and labor

	A unit of final product of IT	Percentage of contribution
Total effects on value added	0.9607	100.00%
Multiplier effects to value added of IT	0.7267	75.64%
Spillover effects to value added of other industry	0.2340	24.36%
Total effects on income	0.6152	100.00%
Multiplier effects to income of IT	0.4813	78.24%
Spillover effects to income of other industry	0.1339	21.76%
Total effects on labor (thousand people)	65.7	100.00%
Multiplier effects to labor of IT(thousand people)	38.3	58.28%
Spillover effects to labor of other industry (thousand people)	27.4	41.72%

Source: Calculated from Vietnam's 2022 I.O table

IV. CONCLUSION

In the I.O system (IOS), every industry has its own importance. The importance of an industry is not only the proportion of that industry's value added in GDP, but also the industry's contribution in the economy which the products of that industry participate in the input costs of other industries and how they spread to the output, value added, income and labor of the final products of that industry to another industry.

Research from the I.O table shows that although the ratio of value added to GDP of the IT industry is only about 9,92%, but the ratio of digitalization in the output of the IT industry is created by the final products of other industries in the economy up to 62,4%.

In addition, the study also shows that one billion USD of the IT industry's final products stimulates its own output by 1,358 billion USD; Of which, stimulated from the final product to output of IT is about 1,329 billion USD and stimulated through the use of inputs that are products of other industries, stimulating production of other industries, which in turn stimulates output. IT industry (inter - industry feedback effects) is 0,029 billion USD. In addition, 1 billion USD of the final product of the IT industry not only stimulates its own output but also stimulates the output of other industries by 0,982 billion USD. The total impact of 1 billion USD of final products of the IT industry on the entire economy is 2,339 billion USD. The study also shows which industries in the remaining industries (19 industries) benefit from the IT industry.

Furthermore, the final products of the IT industry not only stimulate its own added value, income, and labor but also those of other sectors in the economy. So it can be seen that if the output of the IT industry increases, it will increase the output, value added, income and labor of other industries.

The study indicates that the domestic IT sector remains underdeveloped and largely highly dependent on imported inputs. For this sector to play a driving role in stimulating the development of other industries, it is not sufficient for the IT sector alone to grow; related sectors must also invest in research and development (R&D) to create supporting and intermediate products for the IT industry. Furthermore, the domestic IT sector itself must evolve to serve as an effective input into the production processes of other sectors.

The agriculture and fisheries sector exhibits strong multiplier effects, despite its declining share in the overall economic structure.

Under the current Leontief-type structure, the manufacturing sector appears to function mainly as a processing and assembly industry, with limited value-added contribution. To enhance its capacity to stimulate other sectors, the manufacturing sector must be supported by the development of auxiliary and supporting industries. Otherwise, its current expansion primarily serves to increase production in other countries, rather than generating domestic economic benefits.

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**Corresponding Author: Fourth Author⁴*

*⁴(International School - Vietnam National University, Hanoi, Vietnam
email: trungdq@vnuis.edu.vn)*