Analysis of Economic Linkages in Thailand's Digital Industry

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Abstract

This study analyzes the economic linkages in the digital industry in Thailand to identify the relationship between the economic multipliers of the digital industry and other industries. This study aims to discover ways to promote and develop Thailand's digital industry and encourage the domestic economy to grow in the same direction. The analysis is divided into two parts: economic linkage and economic multiplier, using the Input-Output Table. The new industry sector codes are grouped by size, with 59 out of 180 production sectors being evaluated in 2015. According to the Production Factors and Output Table, digital industry activities have a direct forward linkage with other industrial branches, equating to 0.320, and a direct backward linkage with other industrial branches, equating to 0.926. Regarding the analysis of the overall economic linkage index, digital industry activities have an overall forward linkage index and an overall backward linkage index greater than the average or greater than 1, equating to 5.405 and 5.359, respectively. This means that digital industry activities involve the distribution of output and the use of inputs from other production branches. Moreover, an analysis of the multiplier in the economic system reveals that digital industry activity has an average multiplier of 1.910%. This means that if the digital industry activity value increases by 1%, then the value of the output of all industries in Thailand's economy will increase by 1.910%.

The findings suggest that various activities exist in the digital industry. These include the manufacture of radio, television, and communications equipment and tools, postal, telegraph, telephone, and communications services, movie production and distribution, movie theater and radio, television, and other related services. The products are distributed as a factor of production, and there is demand for them from various branches of the economy. Therefore, the government should adopt policies and strategies to develop and promote economic branches linked to digital industry activities. Providing government agencies support and promote economic branches correctly, these economies will expand, potentially bringing other related economic branches to expand in the same way, resulting in the efficient growth of Thailand's economic system. Digital industry is the infrastructure for technological development and innovation in the production processes of all industries.

Keywords: 1) Digital Industry 2) Economic linkages 3) Input-Output Table

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Introduction

Thailand has plans for continuous economic and industrial development. The overall growth of the Thai economy in 2022 was 2.6% as a result of the tourism sector's recovery and continued improvement in domestic demand. Both private consumption and investment spending expanded by 6.3%, whereas private investment expanded by 5.1%, accelerating from 0.6% and 3.0% in 2021, respectively (Office of the National Economic and Social Development Council, 2023, pp. 1–7). Through the promotion of development and investment in technology, innovation, and digital technology, Thailand is entering an industrial era of the digital world, where technology can be clearly used to help innovate and develop human work. This reflects that the world has entered the digital transformation era. For this reason, most government and private sector organizations must invest more in technology and digital innovation. Whether used in the present or future, these technologies can create satisfaction among employees and customers. Every sector is undergoing digital transformation, which will lead to advancements in many aspects of organizational management.

An overview of the Thai digital industry in 2022 shows 14% growth, with a total value of 2,614,109 million baht. The digital service industry has the highest level of expansion, through various platforms, growing in 2021 to 21% with a value of 281,515 million baht. This trend is followed by the software industry, which grew by 19% to a value of 190,766 million baht, whereas the hardware industry and smart devices grew by 18% to a value of 1,431,980 million baht, with continuous growth forecast until 2025. (Digital Economy Promotion Agency, 2023, pp. 1–3)

Nowadays, the digital industry is very important, creating many investment opportunities in the areas of E-Commerce, IoT, digital content, and cloud computing, with an ecosystem ready to develop into a leader in the digital economy. In addition, the government aims to develop digital infrastructure. This will propel Thailand to become one of the best digital investment destinations in Southeast Asia. Furthermore, the digital industry cluster in the Eastern Economic Corridor Innovation Zone (EECi) is a project designed to develop areas in the EEC to serve as a model for bringing innovation to drive new industries that use advanced technology and to adjust the existing industrial base in the area. Accordingly, the extent to which the digital industry affects changes in other industries in the Thai economic system, both directly and indirectly, remains to be proven, including the efficiency of private investment and the expenses involved in attending to government policy on the digital industry in Thailand.

Research Objective

To analyze the connections and economic multipliers of the digital industry with other industries.

Theoretical Background

Table of Inputs and Outputs

The Russian economist, Wassily Leontief, developed a table of production factors and outputs (Input-Output Model) as a tool

for macroeconomic analysis. The concept has received widespread attention and application because it makes general equilibrium analysis easy and less wasteful by using the following assumptions (Kasrisom, 2019, pp. 34–42):

1. In the table of production factors and outputs, industries are interrelated in that Industry A uses the output of other industries (including its own) as inputs for production, while the output of Industry A is also used as a factor for production in other industries. The relationship between output and various production factors must be linear. This is an important characteristic and has led researchers to use the table to calculate the number of goods various industries must produce to satisfy the final demand that the economy must produce to serve them.

2. In the Input-Output Table, the quantity of a product's supply or demand represents the entire industry. It includes the demand of every consumer or the supply of every company. The product is determined and considered to be part of the final demand from government consumers and investment.

3. In producing various types of goods, fixed proportions of various production factors must be used. In other words, the production function has a constant profit size characteristic.

Connection of Production Branches

There is a forward and backward linkage between production branches. The idea of a forward and backward linkage between industries was introduced by Hirschman (Yiamyod and Kaenmanee, 2015, p. 26). It is used in planning economic development and structural changes based on the linkage of relationships with small industries that affect the entire economy.

From the structure production factors and outputs (Input-Output Table), the concept of creating growth can be developed for use as a tool in policy analysis, economic planning, industrial production, and economic impacts in various industries. This demand function is called a backward linkage and is caused by the market supporting the output to be produced in the industry to expand production and benefit the economy in terms of generating other production activities. At the same time, an increase in production from other industries leads to the industry being required to provide more as a production factor to support the increasing demand. The supply function is called forward linkage. A high industry forward linkage means that its output is sensitive to changes in the production of other industries.

Overall Connection

Linkages in each industry sector are considered activities occurring between the activities of various industries related to each other, creating additional activities. An industry can be upstream or downstream, depending on whether it is connected forward or backward overall.

Direct Coefficients

The assumptions of the factors of production (input) and output stipulate that in each economic branch, is directly proportional to the value of production (output). These are taken to find the direct coefficient of the factors of production and output. The direct coefficient represents the production

and value of various economic branches used as intermediate inputs to produce output for one economic branch compared with the total value of that economic branch.

Final Demand

Analysis of changes in final demand is caused by increases in other factors, including consumption, investment, government expenditure, exports, and imports. Equations are used to show the balance (material balance equations) in the form of mathematics.

Literature Review

Today's digital economy has become an important force in reshaping the competitive global landscape. To comprehensively explore the scope and economic importance of the digital industry, this study analyzes the interdependent effects of digital industries and the structural characteristics of industrial networks. The results indicate the following: (1) The primary sector of the digital industry relies heavily on secondary industries as its foundation, using resources to drive development. Meanwhile, these key sectors support the tertiary industry, facilitating its transformation and upgrading. (2) The digital industry plays the role of a backward-linking sector within the industrial chain. It serves as a middle-class demand-driven industry that promotes change and growth in other industries. (3) China’s industrial networks exhibit characteristics of both scale-free networks and small-world networks, with uneven connectivity between industrial fields. (4) The basic digital sector is at the edge of the network and has not yet developed its main advantages. The core digital sector has not yet emerged as a leading industry but has become an important department within the industrial system. This indicates the increasing dominance of the digital industry in the overall economy (Yu, et al., 2023, pp. 1–22)

Quantifying the digital economy and evaluating economic growth in Vietnam provides a direct comparison between Vietnam and Thailand. Together they reveal valuable insights: Firstly, Vietnam's digital economy, valued at US$17,458 and 7.9% of GDP in 2018, continued to expand from 2012–2018. Secondly, the Information and Communication Technology (ICT) sector, especially foreign-invested ICT hardware production, contributes approximately 50% to Vietnam's digital economy, while the contribution from backlinks and digital transformation accounts for 20–30%. Thirdly, the contribution of the non-ICT sector to the digital economy is measured through three channels. These include purchasing digital products and services, providing the ICT sector, and creating added value from digital transformation within the sector. Lastly, when compared to Thailand, Vietnam lags in key digital economy indicators. Specifically, the Thailand/Vietnam ratio for value added in 2018 was 3.9 for the entire digital economy, 3.2 for the ICT sector, 3.1 for engagement from backward linkages. This insight reinforces that while investing in digital infrastructure is important, so is promoting the use of the Internet and attracting FDI to ICT hardware manufacturing (Vu and Nguyen, 2024, pp. 1-20).

In assessing the structural role of the industrial sector within the economy, It is necessary to consider the relationships with other

sectors such as ICT, one of the key innovation accelerators or engines of economic growth. The findings from the structural analysis on changes in linkages are as follows: Firstly, ICT manufacturing shows a higher degree of heterogeneity than the ICT services sector in terms of structural sensitivity effects. This is an indication that the sector needs to be adopted by a wide range of other industries. Secondly, the spectrum of industries that have significant production and stimulating links with the ICT industry is limited, even more so now that the influence of the ICT manufacturing sector has decreased significantly, although the impact of ICT industry sensitivities has increased. Finally, these findings call for sustained policy efforts to promote a virtuous circle in the international production incentive system. Overall, there is increasing use of products and services from other sectors by the ICT sector (especially ICT production), as well as the application of ICT in other sectors. (Heo and Lee, 2019, pp. 424–454).

Branches of the electronics industry in Thailand with the most direct connections include the production of other electrical appliances, electric capacitor batteries, and other branches, respectively. Moreover, the branches with the most direct back-to-back connections include the production of radio, television, and transportation equipment and tools, household electrical appliances and equipment, and other branches, respectively. In terms of overall connectivity, the electronics industry was found to create more overall forward connectivity than backward connectivity (Bhongchirawattana and Srithongdeang, 2019, p. 33). The digital industry sectors can be divided into the following five categories (Digital Economy Promotion Agency, 2017, pp. 1-3):

1. Software and software services industry
2. Hardware and smart device industry
3. Digital service industry
4. Digital content industry
5. Big data industry

According to the literature review, the digital industry is very interconnected with other industries, investing in digital infrastructure, or the basis of development in all aspects of changing the production processes of other industries, promoting the use of the Internet, and attracting domestic investment and foreign direct investment. As a result, the economy of each country has expanded rapidly. Some countries have taken measures to promote the development of the digital industry, one of them being Thailand.

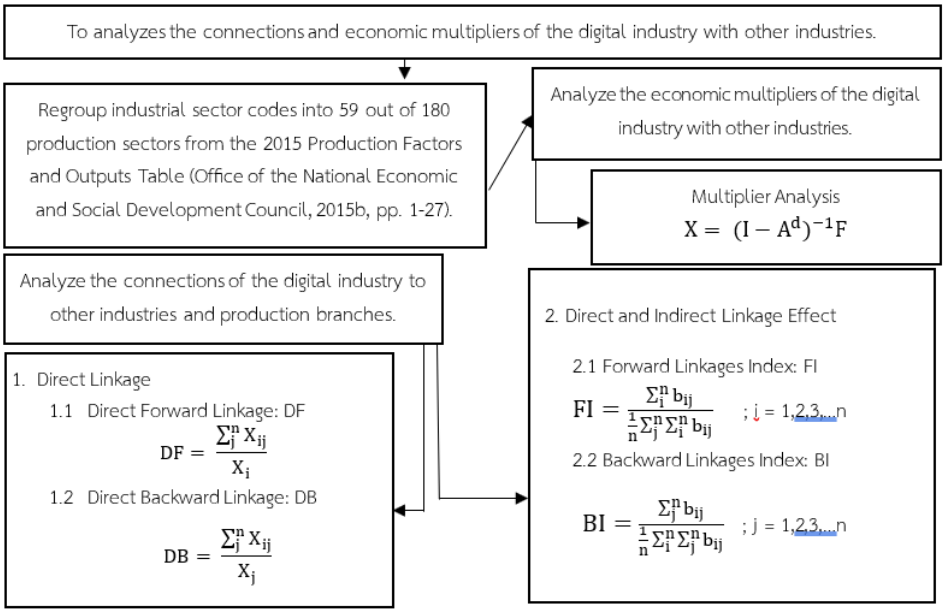

Figure 1 Research Conceptual Framework

Methods

Scope of industry studied: Target industries have been defined according to the Thailand 4.0 policy, which uses principles based on the country's industrial development strategy for a 20-year period (2017–2036). The types of digital industry data are as follows:

Scope of study period: The production factors and outputs are collected every five years using the table of production factors and outputs in 2015 at the level of 180x180 branches, regrouped (mapped) to be in line with the determination of the Thai Industrial Development Strategy 4.0, twenty-year period (2017–2036) of the digital industry group. Only a table of production factors and outputs at the level of 59x59 branches exists (Ministry of Industry, 2015, pp. 9-11). Data on intermediate consumption, final consumption, intermediate production costs, total domestic production, aggregate demand, and additional income or value are used, and prepared by the National Economic and Social Development Board (published in 2022).

Scope of research: Quantitative research using data from the table of production factors and outputs is conducted every five years. The current table of production factors and outputs was prepared in 2015. In this study, these are grouped into industrial sector codes according to the new size of 59 out of 180 production branches (Office of the National Economic and Social Development Council, 2015a, pp. 1–23). In addition, code 53 is assigned to production activities in the digital industry and consists of five codes: 118 (manufacture of radio, television, and communications equipment and tools), 159 (postal, telegraph, telephone, and communications services), 172 (movie production and distribution), 173 (movie theater), 174 (radio, television, and other related services). Documents from relevant government and private agencies were collected as secondary data and analyzed. Later, information on the production structure and final demand value from

the Table of Production Factors and Outputs (Input-Output Table) prepared in 2015 (Office of the National Economic and Social Development Council, 2015b) was used to increase the 59 x 59 production branches from the size of 180 x 180 to be consistent with the analysis, as shown in Table 1.

Scope of the study: Wassily Leontief, the Russian economist, developed the table of inputs and outputs (Input-Output Model) to show the flow of goods and services between various production sectors in the economy over a clear period of time. The structure of the production factors and output table are shown in Table 2.

The structure of the production factors and output table consists of four parts: the behavior between production factors and output (Transaction Table: x_{ij}), the value of final consumption or final demand (Final Demand: F_i), basic production factors or the added value of each economic branch (Value Added: V_j), and the total value of production factors (Total Input: x_j) (Total Demand = Intermediate Demand + Final Demand).

The economic activity (Inter-Industrial Transactions) can be described in algebraic form as follows: The horizontal side (Row) shows the distribution of output in industry i, assuming n is the production branch.

Table 1 Grouping of 59 industrial sectors in production from the table of production factors and outputs.

Code	Production branch	IO-code	Code	Production branch	IO-code
1	Paddy	001	31	Oil refinery	093-094
2	Maize	002	32	rubber products	095-097
3	Cassava	004	33	Plastic ware	098
4	Beans and nuts	006	34	Cement and concrete products	102-103
5	Vegetables	007	35	Other non-metallic products	099-101, 104
6	Fruits	008	36	Iron and steel	105-106
7	Sugar cane	009	37	Non-ferrous metal	107
8	Rubber	016	38	Fabricated metal products	108-111
9	Other crops	003, 005, 010-015, 017, 024	39	industrial machinery	112-115
10	Livestock	018-023	40	Machinery and electrical equipment	116-117, 119-122
11	Forestry	025-027	41	Automotive and repairs	125-127
12	Fishing	028-029	42	Other transportation equipment	123-124, 128
13	Crude oil and coal	030-031	43	Leather products	075-077

Code	Production branch	IO-code	Code	Production branch	IO-code
14	Metal ore	032-035	44	Sawmills and wood products	078-080
15	Non-metallic minerals	036-041	45	Other products	129-134
16	Slaughtering	042	46	Electricity and gas	135-136
17	Processing and food	043-048	47	Water work and supply	137
18	Milling rice and other grains	049-052	48	Building construction	138-139
19	Sugar	055	49	Public works and other construction	140-144
20	Other food	053-054, 056-060	50	Buying and selling	145-146
21	Animal feed	061	51	Restaurants and hotels	147-148
22	Drink	062-064	52	Transportation	149-158
23	Tobacco processing and products	065-066	53	Digital industry activities	118, 159, 172-174
24	Spinning, weaving, and bleaching	067-069	54	Banking and Insurance	160-162
25	Textile products	070-074	55	Real estate	163
26	Paper and paper products	081-082	56	Business services	164
27	Printing and publish-ing	083	57	Public service	165-169
28	Basic chemical products	084,086	58	Other services	170-171, 175-179
29	Fertilizer and pesticides	085	59	Unclassified	180
30	Other chemical products	087-092			

Source: Prepared by the researcher according to the Office of the National Economic and Social Development Council, 2015

$$X_i = \sum_{i=1}^{n} X_{ij} + F_i \quad ; i = 1,2,\ldots,n \qquad (1)$$

where X_{ij} is the circulation of goods in industry i to produce goods of industry j.

X_i is the value of industrial output i

F_i is the final demand for industry i

n is the total number of production branches considered in the economy.

$$X_j = \sum_{j=1}^{n} X_{ij} + V_j \quad ; j = 1,2,\ldots n \qquad (2)$$

where X_{ij} is the circulation of goods of industry i to produce the goods of industry j.

X_j is the total output value of production branch j

V_j is the value added or basic production factors of production branch j

n is the total number of production branches considered in the economy.

Table 2 Structure of the production factors and output table.

Production branch		Intermediate factors of production				Final consumption					Aggregate demand
						C	I	G	X	M	
Intermediate factors of production	in the country	X_{11}	X_{11}	...	X_{1j}	C_1	I_1	G_1	X_1	M_1	X_1
		X_{11}	X_{11}	...	X_{2j}	C_2	I_2	G_2	X_2	M_2	X_2
	Import	:	:	...	:	:	:	:	:	:	:
		:	:	...	:	:	:	:	:	:	:
		X_{i1}	X_{i2}	...	X_{ij}	C_i	I_i	G_i	X_i	M_i	X_i
		X_{m1}	X_{m1}	...	X_{mj}	C_m	I_m	G_m	X_m	M_m	X_m
		:	:	...	:	:	:	:	:	:	:
		X_{mn}	X_{mn}	...	X_{mn}	C_{mn}	I_{mn}	G_{mn}	X_{mn}	M_{mn}	X_{mn}
Added value	Salary, wages	L_1	L_2	...	L_{ij}						
	Production returns and depreciation	K_1	K_2	...	K_{ij}						
	Net indirect tax	T_1	T_2	...	T_{ij}						
Added value		V_1	V_2	...	V_{ij}						
Total domestic production		X_1	X_2	...	X_{ij}						

Note: 1) Production returns include those from all production factors.
2) C is the final household consumption, I is investment, G is government expenditure, X is exports, and M is imports (where I, j ranges from 1 to 59)

The relationship in the structure of production factors of each vertical production branch (column) can be expressed in algebraic form as follows.

1. Analysis of the Direct Linkage and Overall Linkage Index of the Digital Industry With Other Industries

Direct linkage analysis involves the calculation of direct forward linkage (DF) and direct backward linkage (DB). The analysis of the overall linkage index (direct and indirect linkage effect) involves the calculation of the overall forward linkage index (FI) and the overall backward linkage index (BI) of one branch of production that is related to others. Using data from the country's production factor and output table for 2015, the researcher organized a new group from Table 1, calculated from the formula.

1.1 Direct Forward Linkage: DB

$$DF = \frac{\sum_j^n X_{ij}}{X_i} \quad (3)$$

where DF is the direct forward linkage

X_i is the total demand value of the branch

$\sum_j^n X_{ij}$ is the sum of the intermediate demand for the output of branch i that other output branches use as factors of production.

n is the total number of production sectors of the economy.

1.2 Direct Backward Linkage: DB

$$DB = \frac{\sum_i^n X_{ij}}{X_j} \quad (4)$$

where DB is the direct backward linkage

X_j is the total value of production factors of branch j.

$\sum_i^n X_{ij}$ is the sum of the overall intermediate production factors used by production branch i.

n is the total number of production sectors of the economy.

If DF and DB have high values, this means there is a strong relationship with other industrial branches. However, if the value is low, it means there is little connection with other industrial branches.

Direct Coefficients: a_{ij}

The use of production factors (Input) is directly proportional to the value of output (Output), as shown in the following equation:

$$X_{ij} = a_{ij} \cdot X_j \quad \text{or} \quad a_{ij} = X_{ij}/X_j \quad (5)$$

where a_{ij} is the direct coefficient or input or technical coefficients, meaning the proportion of production factors i used in the production of industrial product j.

$$A = \begin{vmatrix} \frac{X_{11}}{X_1} & \frac{X_{12}}{X_2} & \cdots & \frac{X_{1n}}{X_n} \\ \frac{X_{21}}{X_1} & \frac{X_{22}}{X_2} & \cdots & \frac{X_{2n}}{X_n} \\ \downarrow & \downarrow & \cdots & \downarrow \\ \frac{X_{n1}}{X_1} & \frac{X_{n2}}{X_2} & \cdots & \frac{X_{nn}}{X_n} \end{vmatrix} = \begin{vmatrix} a_{12} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \downarrow & \downarrow & a_{ij} & \downarrow \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{vmatrix} \quad (6)$$

where X_{ij} is the value of the output of production branch i which is used as a production factor to produce goods of production branch j.

X_j is the value of total output of production branch j

a_{ij} is the proportion of the value of intermediate domestic production factors of type i used in the production of branch j relative to the output value of production branch j

n is the total number of production sectors in the economy.

The overall industry connectivity can be calculated using the metric A factor coefficient table to obtain the value of the Leontief Inverse Matrix $[I\text{-}A^d]^{-1}$. The Leontief Inverse Matrix value can be calculated as follows.

$$[I\text{-}A^d] = \begin{vmatrix} 1 & 0 & \cdots & 0 \\ 0 & 1 & \cdots & 0 \\ \downarrow & \downarrow & 1 & \downarrow \\ 0 & 0 & \cdots & 1 \end{vmatrix} - \begin{vmatrix} a_{12} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \downarrow & \downarrow & a_{ij} & \downarrow \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{vmatrix} \quad (7)$$

The results from [I-A] can be used to perform an Inverse Matrix, which will result in the following:

$$[I\text{-}A^d]^{-1} = \begin{vmatrix} b_{12} & b_{12} & \cdots & b_{1n} \\ b_{21} & b_{22} & \cdots & b_{2n} \\ \downarrow & \downarrow & \cdots & \downarrow \\ b_{n1} & b_{n2} & \cdots & b_{nn} \end{vmatrix} \quad (8)$$

Industry linkages are considered activities that occur between industries related to each other, causing them to increase. The industry can be either upstream industry (Upstream) or downstream (Downstream), depending on whether the industry is connected overall forward or backward when considering the model and index equations.

The Leontief Inverse Matrix [I-Ad]-1 can be used to calculate the forward and BI values according to the following formula:

1.3 Forward Linkage Index: FI

$$FI = \frac{\sum_i^n b_{ij}}{\frac{1}{n}\sum_j^n \sum_i^n b_{ij}} \quad ; i = 1,2,3,...n \qquad (9)$$

Where FI is the forward linkage index

$\sum_i^n b_{ij}$ is the horizontal sum of the matrices. $(I\text{-}A^d)^{-1}$

$\sum_j^n \sum_i^n b_{ij}$ is the sum of the vertical sides of the matrix. $(I\text{-}A^d)^{-1}$

n is the total number of production sectors of the metric $(I\text{-}A^d)^{-1}$

i is 1,2,3,...n

1.4 Backward Linkage Index: BI

$$BI = \frac{\sum_j^n b_{ij}}{\frac{1}{n}\sum_i^n \sum_j^n b_{ij}} \quad ; j = 1,2,3,...n \qquad (10)$$

Where BI is the backward linkage index

$\sum inb_{ij}$ is the sum of the vertical sides of the matrix. $(I\text{-}A^d)^{-1}$

$\sum_j^n \sum_i^n b_{ij}$ is the sum of all horizontal sides of the matrix. $(I\text{-}A^d)^{-1}$

n is the total number of production sectors of the metric. $(I\text{-}A^d)^{-1}$

i is 1,2,3,...n

The FI and BI values mean that a BI value greater than 1 indicates that the digital industry receives more raw materials from other production branches than the average received by all production branches. In addition, a BI of less than 1 indicates that the digital industry receives fewer raw materials from other production branches than the average received by all production branches.

Moreover, an FI greater than 1 indicates greater distribution of output to other production branches than the average across all production branches. An FI of less than 1 indicates that the distribution of output to other production branches is less than the average across all production branches.

2. Multiplier Analysis

To analyze the economic multiplier, the direct and indirect coefficients of production must be known first. This value can be calculated by inverting the identity matrix (Matrix l: Identity Matrix) with the domestic intermediate production factor coefficient matrix (Matrix A) as follows (Bhongchirawattana and Srithongdeang, 2019, p. 26):

$$X = AX + F \qquad (11)$$

$$X(I - A^d)^{-1} = F \qquad (12)$$

$$X = (I - A^d)^{-1} F \qquad (13)$$

Where X is the vector of multiplier in the output of each production branch

F is the final demand vector

I is the identity matrix vector

A is the output vector in each production branch.

$(I\text{-}A^d)^{-1}$ is the Local Leontief Matrix

Matrix $(I\text{-}A^d)^{-1}$ or matrix B refers to the Direct and Indirect Production Coefficients Matrix or Leontief's Domestic Matrix, described as when the final demand of economic branch

j changes by 1%, it causes a production change in economic branch i. This can occur both directly and indirectly according to the direct and indirect coefficient of production in [I-Ad]-1%.

Results

1. Analysis of the Direct Linkage and Overall Linkage Index of the Digital Industry Activities in Comparison With Other Industries

The analysis of the economic direct linkage of the digital industry presented in Table 3 shows that digital industry activities have a DF linkage of 0.320, meaning that they had the most DF relationship with other industrial branches, equating to 0.320, while the DB linkage equated to 0.926, meaning that digital industry activities had the most DB relationship with other industrial branches.

An analysis of direct linkages in groups of digital industry activities (53). Movie production and distribution (172) had the highest DF linkage with other branches, equating to 1.000, followed by radio, television, and other related services (174), postal, telegraph, telephone, and communications services (159), movie theater, (173), and manufacture of radio, television, and communications equipment and tools (118), equating to 0.899, 0.624, 0.068, and 0.045, respectively. (Table 4) The analysis of direct linkages among digital industry activities (53) revealed that movie theater (173) had the highest DB linkage, equating to 3.373, followed by movie production and distribution (172), radio, television, and other related services (174), manufacture of radio, television, and communications equipment and tools (118), and postal, telegraph, telephone, and communications services (159) were 3.225, 1.393, 1.286, and 0.595, respectively.

Analysis of the Overall Linkage Index of the Digital Industry Activities in Comparison With Other Industries

An analysis of the overall economic linkage index of the digital industry. The digital industry activities had an overall FI of 5.405 (Table 3). An FI greater than 1 indicates a greater distribution of output to other production branches than the average distribution of output across all production branches. This means that digital industrial activity is a branch that diversifies its output as a production factor for other branches of production. If the digital industry is affected, so will other production branches that use production factors from it, with the field of production changing accordingly.

Moreover, digital industry activities have an overall BI of 5.359. A BI greater than 1 indicates that more raw materials are received from other production branches than the average raw material intake for all production branches. This means that digital industrial activity demands comparative inputs from other branches.

An analysis of the overall economic linkage index in groups of digital industry activities (53), revealing that postal, telegraph, telephone, and communications services (159) had the highest overall FI, equating to 1.728, followed by radio, television, and other related services (174) and movie production and distribution (172), equating to 1.326 and 1.027, respectively (Table 4). An FI greater than 1 in-

dicates a greater distribution of output to other production branches than the average across all production branches. This means these branches diversify their products as inputs for production in other branches.

Furthermore, the manufacture of radio, television (118), and communications equipment and tools, as well as movie theater (173), have overall forward linkage indexes of 0.743 and 0.581, respectively, with an FI of less than 1, indicating that the distribution of output to other production branches is less than the average across all production branches. Therefore, these branches are not diversifying production or using their own products as the main production factor. Whereas postal, telegraph, telephone, and communications services (159), radio, television, and other related services (174), and movie production and distribution (172) are branches of production that help in distributing production from one branch to another. If production is affected in these fields, it will result in other branches that use production factors experiencing changes as well. On the other hand, if the manufacture of radio, television (118), communications equipment and tools, and movie theater (173) are affected, other fields that use factors of production will not be affected.

The analysis of the overall BI indicates that movie theater (173) had the highest linkage, equating to 1.397, followed by radio, television, and other related services (174) and movie production and distribution (172), equating to 1.159 and 1.130, respectively. A BI greater than 1 indicates that the branch receives more raw materials from other production branches than the average for all production branches. This means that these branches demand inputs from other branches.

Moreover, the manufacture of radio, television (118), and postal, telegraph, telephone, and communications services (159) are shown to have overall forward linkage indexes of 0.743 and 0.581, respectively, with a BI of less than 1, indicating that they receive fewer raw materials from other production branches than the average for all production branches. This means that these branches use their own products as the main production factor. The production branches of movie theater (173), radio, television, and other related services (174), and movie production and distribution (172) are shown to receive raw materials from other production branches rather than their own branches. If there is an impact on other fields that use raw materials in production, it will result in a comparative change in the manufacture of radio, television (118), and postal, telegraph, telephone, and communications services (159) since these fields of production mainly use raw materials produced by themselves. Consequently, such an impact, will not affect the production branch.

Table 3 Analysis of the direct linkage and economic multipliers of the digital industry in comparison with other industries.

Code	Production branch	Direct linkage		Overall linkage index		Output Multipliers
		DF[1]	DB[2]	FI[3]	BI[4]	
1	Paddy	0.967	0.366	1.600	0.784	0.909
2	Maize	0.541	0.560	1.415	0.868	1.037
3	Cassava	1.147	0.497	1.276	0.846	0.699
4	Beans and nuts	1.006	0.657	0.664	0.883	0.112
5	Vegetables	0.299	0.492	0.769	0.843	0.251
6	Fruits	0.449	0.500	0.915	0.845	0.496
7	Sugar cane	1.000	0.631	1.243	0.892	0.537
8	Rubber	0.609	0.274	1.176	0.755	0.771
9	Other crops	0.933	0.670	8.389	9.622	3.378
10	Livestock	0.804	1.197	4.508	6.162	1.112
11	Forestry	1.718	0.315	2.266	2.418	0.647
12	Fishing	0.684	0.898	1.680	1.997	0.744
13	Crude oil and coal	1.155	0.573	3.585	1.877	0.782
14	Metal ore	7.493	0.591	2.509	4.190	0.190
15	Non-metallic minerals	1.579	0.710	4.681	5.606	1.463
16	Slaughtering	0.376	2.156	1.091	1.278	0.767
17	Processing and food	0.173	3.185	4.204	7.264	0.951
18	Milling rice and other grains	0.229	4.468	3.450	4.731	1.541
19	Sugar	0.484	1.574	1.244	1.119	0.966
20	Other food	0.323	1.934	4.594	8.009	0.746
21	Animal feed	1.400	2.841	1.413	0.986	1.105
22	Drink	0.320	0.797	2.080	2.929	0.422
23	Tobacco processing and products	0.179	0.280	1.243	2.058	0.141
24	Spinning, weaving, and bleaching	0.622	1.420	3.166	3.138	1.963
25	Textile products	0.138	1.921	3.500	5.769	0.668
26	Paper and paper products	0.846	1.205	1.907	1.771	0.812
27	Printing and publishing	0.586	1.319	0.896	0.937	0.249
28	Basic chemical products	0.535	1.320	3.659	1.910	2.242
29	Fertilizer and pesticides	1.399	1.756	1.820	0.946	1.345
30	Other chemical products	0.810	1.313	5.179	6.020	2.153
31	Oil refinery	0.628	0.985	6.426	1.496	4.962

Code	Production branch	Direct linkage		Overall linkage index		Output Multipliers
		DF[1]	DB[2]	FI[3]	BI[4]	
32	rubber products	0.209	2.634	2.184	3.133	0.488
33	Plastic ware	0.408	2.232	1.495	1.102	1.085
34	Cement and concrete products	1.155	1.597	2.219	2.265	1.522
35	Other non-metallic products	0.489	1.990	2.903	4.648	0.776
36	Iron and steel	1.406	2.949	4.007	2.889	2.612
37	Non-ferrous metal	0.252	0.937	0.793	0.851	0.302
38	Fabricated metal products	0.177	1.146	3.090	3.731	0.981
39	industrial machinery	0.369	1.181	3.819	3.655	1.711
40	Machinery and electrical equipment	0.305	2.161	4.823	5.565	1.351
41	Automotive and repairs	0.171	1.213	3.378	2.736	1.537
42	Other transportation equipment	0.289	1.281	2.060	3.045	0.441
43	Leather products	0.183	1.121	1.819	2.564	0.094
44	Sawmills and wood products	0.268	1.489	2.327	3.153	0.814
45	Other products	0.214	1.717	4.156	5.784	0.862
46	Electricity and gas	0.732	1.509	7.535	2.223	5.275
47	Water work and supply	0.506	0.491	0.776	0.882	0.219
48	Building construction	0.063	2.927	1.353	2.319	0.202
49	Public works and other construction	0.000	1.808	2.881	5.529	0.000
50	Buying and selling	0.531	0.244	10.100	1.520	10.197
51	Restaurants and hotels	0.057	1.765	1.713	2.313	0.556
52	Transportation	0.377	1.770	9.404	10.478	4.005
53	**Digital industry activities**	**0.320**	**0.926**	**5.405**	**5.359**	**1.910**
54	Banking and Insurance	0.597	0.417	5.887	2.446	3.301
55	Real estate	0.231	0.268	1.141	0.783	0.394
56	Business services	0.784	1.436	3.616	1.153	2.632
57	Public service	0.023	0.269	3.139	4.142	0.271
58	Other services	0.125	0.794	3.932	5.573	0.464
59	Unclassified	0.499	2.266	1.496	1.208	1.047

Note: [1]Direct forward linkage from equation (3)

[2]Direct backward linkage from equation (4)

[3]Overall forward linkage index from equation (9)

[4]Overall Backward linkage index from equation (10)

Table 4 Analysis of the direct linkage and economic multipliers in the digital industry (53)

Code[5]	Production branch	Direct linkage		Overall linkage index		Output Multipliers
		DF[1]	DB[2]	FI[3]	BI[4]	
118	manufacture of radio, television	0.045	1.286	0.743	0.739	0.165
159	Postal, telegraph, telephone, and communications services	0.624	0.595	1.728	0.935	0.799
172	Movie production and distribution	1.000	3.225	1.027	1.130	0.599
173	Movie theater	0.068	3.373	0.581	1.397	0.001
174	Radio, television, and other related services	0.899	1.393	1.326	1.159	0.345

Note: [1]Direct forward linkage from equation (3)
[2]Direct backward linkage from equation (4)
[3]Overall forward linkage index from equation (9)
[4]Overall Backward linkage index from equation (10)
[5]IO-Code, Office of the National Economic and Social Development Council, 2015

2. Multiplier Analysis of Digital Industry Activities

The analysis of the multipliers of digital industry activity in Table 3 shows that the multiplier is equal to 1.910, which means that when digital industry activity changes by 1%, other production branches will expand by 1.910%. It can be concluded that the change in the final demand of the activity also improves the digital industry because of changes in the productivity of every branch of production.

The analysis of multipliers of digital industry activities in Table 4 reveals that the greatest multipliers are postal, telegraph, telephone, and communications services (159), followed by movie production and distribution (172), radio, television, and other related services (174), the manufacture of radio, television, and communications equipment and tools (118), and movie theater (173), equating to 0.799, 0.599, 0.345, 0.165, and 0.001, respectively. This means that when every branch of activity in the digital industry changes by 1%, other branches of production will expand by 0.799%, 0.599%, 0.345%, 0.165%, and 0.001%, respectively. It can be concluded that changes in final demand for all branches of activity also increase the activities in the digital industry due to changes in the productivity of every branch of production.

Industries are undergoing a digital transformation to enhance production efficiency, driving the creation of new innovations such as driverless cars and leveraging digital technologies in diverse fields including medicine and agriculture. The digital industry serves as a cornerstone for research and development of cutting-edge technologies and innovations, encompassing internet-connected devices, artificial intelligence, and embedded systems. It supports production processes across all industries, contributing to sustained and sustainable economic growth.

Conclusion and Discussion

The analysis of digital industry activities shows a DF linkage with other industrial branches, equating to 0.320, and a DB linkage with other industrial branches, equating to 0.926. As for the analysis of economic linkages overall, digital industry activities are revealed to have an overall FI greater than the average or greater than 1, indicating that digital industry activities distribute output to other industries at the rate of 5.405%. According to the overall BI, digital industry activities use production factors from other branches of production at the rate of 5.359%, with the overall BI being greater than the average or greater than 1.

According to the analysis of the economic multiplier of digital industry activities, these activities have an average economic multiplier value as high as 1.910 for all production branches. This shows that if digital industry activities increase final demand by 1%, it will result in the production value of all industrial sectors in the economy increasing by 1.910%, ranking twelfth out of a total of 59 industries. The activities have been regrouped (mapped) from the table of production factors and outputs of 180 production sectors in 2015 from the Office of the National Economic and Social Development Council. It can be observed that digital industry activities have a significant impact on the economic system. Therefore, the government should promote and support such activities to promote economic growth.

The focus of the Thailand 4.0 policy (Thailand 4.0) is on the development of digital infrastructure. To provide greater access to the Internet, cooperation with all sectors is required, using the dynamics of change to help the country become a leader in productivity. The areas relating to smartphones, commerce, electronics, receiving electronic payments, digital content, Cloud computing, and fintech are growing significantly in the public, private, government, and international sectors. The potential for growth by improving the digital infrastructure requires the connection of various devices. Using artificial intelligence to replace human labor and increase productivity, information security standards, smart homes, and cities. Industries that support digital technology affect development such as the electrical industry, semiconductor electronics, circuit boards, ICT consulting and services, system development, education, maintenance, media production, social network content, and financial services. All of these are key factors in the development of the digital industry. However, the needs of other industries must be considered for the development of the digital industry to upgrade and increase production efficiency. The process of producing and inventing new products in response to consumer needs and being a leader in that product are essential for growth in both the domestic and international markets.

Research Implementation

This study reveals that the final demand in digital industry activities creates demand for inputs from various production branches, including the manufacture of radio, television, and communications equipment and tools, as well as postal, telegraph, telephone, and communications services. Accordingly, the government should support

these production branches in various aspects, such as increasing production efficiency and developing more modern technology. In addition, emphasis should be placed on postal, telegraph, telephone, and communications services, radio, television, and other related services, and movie production and distribution. This is because they are branches of digital industry activities and have the highest distribution of output as production factors for other branches according to the overall economic connectivity index coefficient.

Therefore, the government should formulate policies and strategies to develop and promote economic sectors that have high rates of connectivity with digital industry activities based on the overall economic connectivity index coefficient. If government agencies support and promote the economic branch correctly, it will result in the expansion of that economy, potentially helping other related economic branches to expand as well. Such branches include cloud computing systems, Internet of Things technology verification/fraud detection analysis using big data, three-dimensional printing technology (3D Printing), and centralizing and linking the data of all government agencies. Most importantly, this development would increase the potential of workers in the digital industry as well as public awareness of various information. In terms of research and development in Thailand's digital industry, the government should focus on products that meet the needs of the service users to raise the productivity of each industry. The government should focus on the agricultural sector, in which most people in the country work, transportation, services, finance, public health, and most importantly, the education sector where labor skills are required to drive and raise the level of Thailand's economic development and growth.

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