An extended variant of the IO model for the study on indirect and direct taxes

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Abstract: Since the input - output (I.O) system was created by W. Leontief, there have been many models expanding from the I.O model such as inter-regional I.O model, inter-national I.O model, social accounting matrix (SAM), demographic - economic model... The I.O model describes and analyzes the flow of products through inter-industrial relationships or the initial distribution process of the economy. The inter-regional I.O model not only reflects inter-industry relationships but also reflects inter-regional relationships, it allows determining the advantage of one region over another in which industries? The social accounting matrix and economic demographic model not only model describes the initial distribution process but also describes the redistribution process. This study extends the I.O model with a harmonious blend of the concept of social accounting matrix and economic demographic model to see that the economy is like a cycle of reincarnation in Buddhism about "no beginning and no end"; any change (Cause) at any stage directly or indirectly affects (Consequences) on the rest.

Keywords: Extended, household, input, multiplier, output, value added.

I. Introduction

Since W. Leontief created the I.O model (1936, 1953, 1941), this model has developed and expanded quite a lot. There are many studies expanding the original standard. /O model, such as the Social Accounting Matrix - SAM (Richard Stone, 1961), System of National Accounts - SNA, Demographic - Economic Model (Miyazawa, 1968, 1971). Combined economic and environmental model (Hybrid I.O) and inter-regional model (Isard, W. (1951), Miyazawa et al., (1976)). These extended IO models have been built and applied by most countries around the world to analyze and forecast the economy (Pyatt and Roe, 1977; Cohen, 1988; Pyatt and Round, 1985). There are various uses on these models such as I/O analysis, inter-regional I.O analysis, SAM analysis and CGE modeling. These analyzes are very diverse based on linear algebra theory and analysis to flexibly transform Leontief's original standard model.

In the demographic-economic model, Miyazawa expanded the I.O table by adding columns showing the final consumption of the corresponding household type and the income row of the corresponding household type. Bui et al (2012, 2017, 2020. 2021) also presented an expanded diagram of the relationships between the supply and demand sides of the economy.

The traditional I.O model shows how the economy's production technology changes, as well as seeing how certain economic sectors promote the development of other sectors through forward and backward linkages. The I.O table is based on the technical norm coefficient matrix A which is considered central, in which the horizontal flow elements reflect the demand for supplying products of industries for the intermediate needs of other industries, but in the new added value reflects employee income, indirect taxes, depreciation and production surplus/mixed income of each economic sector (not reflecting direct taxes such as personal income tax and revenue tax). Enter a business). For final demand, final consumption of households, final consumption of the State, gross accumulation of assets and net exports are clearly divided).

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This study extends the traditional I.O model, it is not only to describe initial distribution, but also describe redistribution by institutional sector; Research using the updated I.O table for 2016 with 3 large industry groups: Industry group 1: Agriculture, forestry and fishery; Industry group 2: Industry and construction; Industry group 3: Service industries

II. Research Methods

The extended I.O model in this study is described:

+ Horizontal lines: Reflecting the income of institutions such as households, the State and the enterprise sector.
+ Vertical rows: represent the branches of the corresponding institutional areas.

The diagram below improves the arrangement and expands it to the corresponding income and expenditure groups. Diagram 1 not only describes the impact of indirect and direct taxes but also quantifies the impact of exports on factors of added value. In a previous study, Bui Trinh (2020) also proposed a method for estimating exports that affect supply-side factors, but this study considers the impact of the demand side to factors of value added through the arrangement of sub matrices.

Table 1. Expanded I/O model diagram

	Intermediate input	Households	Government	GCF (Enterprises)	Rest of the World (RoW)	Total
Intermediate demand	A^dX_1	C^dX_2	$G^d.X_3$	$I^d.X_4$	F_1	X_1
Households	$H_1.X_1$		$H_3.X_3$		F_2	X_2
Government	Indirect Tax ($T_1.X_1$)	Direct tax (T_2,X_2)		Direct tax ($T_4.X_4$)	F_3	X_3
Saving	Operating Surplus ($S_1.X_1$)	$S_2.X_2$	$S_3.X_3$		F_4	X_4
Rest of the World (RoW)	M_1	M_2	M_3	M_4		M
Total	X_1	X_2	X_3	X_4		

Where:

+ X_1 is an gross output vector, X_2 is an vector of total household income, X_3 is Government income including taxes (indirect and direct) and other income from abroad, X_4 is the total income of the enterprise sector.
+ A^d is the matrix of intermediate input coefficients using domestic products.
+ C^d is the vector of final consumption coefficients of the household using domestic products.
+ G^d is the vector of final consumption coefficients of the State using domestic products.
+ I^d is the investment coefficient using domestic products.
+ $+H_1$ is the coefficient of income from production, H_3 is income of the household sector that is receipted by the State sector
+ T_1 is the State's revenue coefficient from indirect taxes (excluding subsidies), T_2 is personal income tax coefficient and T_4 is corporate income tax coefficient.
+ S_1 is the production surplus coefficient, S_2 is the saving coefficient of the household sector, S_3 is the savings coefficient of the State sector.

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+ F_1 is the export of goods and services, F_2 is other non-production income of the household sector from abroad, F_3 is other non-tax income of the State sector from abroad, F_4 is other income of the sector enterprise from abroad.

+ M_1 is import for intermediate costs, M_2 is import for final consumption of households, M_3 is import for final consumption and payment of ownership abroad by the State, M_4 is import for the accumulation and payment of ownership abroad by the enterprises sector.

+ GCF is gross capital formation; RoW (Rest of the World) is the relationship with foreign countries including export, import and cash flow in and out such as payments and receipts from ownership and transfer.

So, we have:

$A^d_1.X_1 + C^d.\ X_2 + G^d.\ X_3 + I^d.\ X_4 + F_1 = X_1$ (1)

$H_1.X_1 + H_3.X_3 + F_2 = X_2$ (2)

$T_1.X_1 + T_2.\ X2 + T4.X_4 + F_3 = X_3$ (3)

$S_1.X_1 + S_2.X_2 + S_3.X_3 + F_4 = X_4$ (4)

$M = M_1 + M_2 + M_3 + M_4$ (5)

Equation (1) is the standard Leontief relation describing the product flow, ($A^d_1.X_1$) represents intermediate consumption; ($C^d.\ X_2$) is household final consumption; ($G^d.\ X_3$) is the final consumption of the State; ($I^d.X_4$) is gross capital formation and F_1 is export of goods and services; X_1 is the output vector.

Relationship (2) shows the total income of household X_2 including income from production $H_1.X_1$, income from transfer from the State sector $H_3.X_3$ and income from other non-production from abroad F_2.

Relationship (3) represents the total revenue of the State sector.

Relationship (4) represents the total income of the enterprises sector

Looking from the supply side from the equations above, we can see:

$A^d.X_1 + H_1.X_1 + T_1.X_1 + S_1.X_1 + M_1 = X_1$ (6)

$C^d.X_2 + T_2.X_2 + S_2.X_2 + M_2 = X_2$ (7)

$G^d.\ X_3 + H_3.X_3 + S_3.X_3 + M_3 = X_3$ (8)

$I^d.\ X_4 + T_4.X_4 + M_4 = X_4$ (9)

Relationship (6) corresponds to relationship (1), relationship (6) represents the supply side: Intermediate costs of using domestic products ($A^d.X_1$), imported products M_1 and added value ($H_1.X_1 + T_1.X_1 + S_1.X_1$).

Relationship (7) shows that household sector savings ($S_2.X_2$) is equal to total income (X2) minus final consumption ($C^d.X_2 + M_2$) and personal income tax ($S_2.X_2$).

Relationship (8) represents total expenditure of the State sector including final consumption expenditure of domestic and imported products ($G^d.\ X_3+M_3$), transfer expenditure to the household sector ($H_3.\ X_3$) and investment expenditure ($S_3.X_3$)

Relationship (9) represents gross capital formation of the enterprise sector from domestic and imported products ($I^d.\ X_4 + M_4$) and corporate income tax ($T_4.X_4$).

Relations (1), (2), (3), (4), (5), (6), (7), (8) can be rewritten in matrix form as follows:

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$$\begin{bmatrix} A^d & C^d & G^d & I^d \\ H_1 & & H_3 & \\ T_1 & T_2 & & T_3 \\ S_1 & S_2 & S_3 & \end{bmatrix} * \begin{bmatrix} X_1 \\ X_2 \\ X_3 \\ X_4 \end{bmatrix} + \begin{bmatrix} F_1 \\ F_2 \\ F_3 \\ F_4 \end{bmatrix} = \begin{bmatrix} X_1 \\ X_2 \\ X_3 \\ X_4 \end{bmatrix} \quad (9)$$

Đặt:

$$B = \begin{bmatrix} A^d & C^d & G^d & I^d \\ H_1 & & H_3 & \\ T_1 & T_2 & & T_3 \\ S_1 & S_2 & S_3 & \end{bmatrix}$$

$$X = \begin{bmatrix} X_1 \\ X_2 \\ X_3 \\ X_4 \end{bmatrix}$$

$$F = \begin{bmatrix} F_1 \\ F_2 \\ F_3 \\ F_4 \end{bmatrix}$$

So we have:

$$BX + F = X \quad (10)$$

Satisfactory Leontief relationship:

$$X = (I - B)^{-1}.F \quad (11)$$

Put: $U = (I - B)^{-1}$

So, U was performed:

$$U = \begin{bmatrix} U^A & U^C & U^G & U^I \\ U^{H_1} & & U^{H_3} & \\ U^{T_1} & U^{T_2} & & U^{T_3} \\ U^{S_1} & U^{S_2} & U^{S_3} & \end{bmatrix} \quad (12)$$

and equation (7) was re-written as follow:

$$X = U.F \quad (13)$$

According to Michael Sonis and Geoffrey Hewings (1993), Bui, T (2020); (U^A) is called the extended Leontief inverse matrix, this matrix can be explicitly analyzed including direct effects A^d, indirect effects $[(I - A^d)^{-1} - A^d]$ and spillover effects from household final consumption, State final consumption and investment: $[U^A - (I - A^d)^{-1}]$ and it is easy to see $(I - A^d)^{-1}$ is the spillover from exports to prices production value by industry.

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The Induced impacts of an exporting unit to the factors of value added is determined as below:

$$V = \begin{bmatrix} U^{H_1} \\ U^{T_1} \\ U^{S_1} \end{bmatrix} \quad (14)$$

Here, the matrix V can be expressed as follows:

U^{H1} is the spillover of an export unit to the income of workers
U^{T1} is the spillover of an export unit to indirect tax
U^{S1} is the spillover of an export unit to operating sủplus

Therefore, the matrix M is considered an expanded Miyazawa multiplier matrix:

$$M = \begin{bmatrix} & U^{H_3} & \\ U^{T_2} & & U^{T_3} \\ U^{S_2} & U^{S_3} & \end{bmatrix} \quad (15)$$

And Q is the matrix on output was induced by factors of domestic final demand

$$Q = \begin{bmatrix} U^C & U^G & U^I \\ & & \\ & & \end{bmatrix} \quad (16)$$

Matrix M represents the "multiplier effects" from other income and income from production to current transfer income from the State sector to the household sector (U^{H3}); to personal income tax (U^{T2}), corporate income tax (U^{T3}); and household sector savings (U^{S2}), corporate sector savings (U^{S3}).

Perhaps Miyazawa's most important contribution is associated with his analysis of the structure of income distribution (see Miyazawa, 1976 for the most complete presentation). The insights he provided stimulated what might be called the "onion skin" approach to economic-demography. Approaches in this research attempt to expanded Miyazawa model for linking the the demographics and economics of an economy. These linkages will reveal the effects of changes in economic actions on income distribution, labor force status or migration behavior and the effects of changes in spending such as: Household consumption expenditure, State expenditure and corporate sector expenditure on investment and corporate income tax, employment status, etc. for economic activities.

Thus, the matrix U can be rewritten as below:

$$U = \begin{bmatrix} U^A & U^A.Q \\ & \\ V.(I - A^d)^{-1} & I + V.A^d.Q \end{bmatrix} \quad (17)$$

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Thus, despite expansion, the Leontief system's computational relationships are still preserved, making it very convenient for research and analysis.

III. Experimental study

The data for compiling this model based on the updated I.O table, 2016 and data collected through the websites of the Ministry of Finance and the State Bank. The expanded IO model with 3 large industry groups (group 1: Agriculture, forestry and fisheries, group 2: Industry and construction, group 3: Services) is built in table 1. In the model below Here, expenses are expressed in columns and income is expressed in rows.

Table 1. Expanded I.O model (trillions)

	Sector group 1	Sector group 2	Sector group 3	Household	Government	Enterprises	Rest of the World	**Total**
Sector group 1	460	1,036	40	467	-	61	112	2,176
Sector group 2	536	4,223	743	807	-	793	3,148	10,250
Sector group 3	129	652	804	1,005	268	24	573	3,455
Household	482	1,142	992		10	12	590	3,228
Government	39	314	168	100		350	50	1,021
Enterprises	194	683	489	100	721		57	2,244
Rest of the World	336	2,200	420	750	22	1,005		4,731
Total	2,176	10,250	3,655	3,228	1,021	2,244		

Source: Estimated by author

In general, Table 2 shows that spillover from exports to production value of all three industry groups is higher than spillover from domestic final demand (consumption and accumulation demand). Calculation results show that the spillover from exports to the output of industry group II is highest and the spillover is lowest to the output of industry group III. On the contrary, it spreads from domestic demand (final consumption and investment) to the highest service industry group, followed by industry group I and finally industry group II.

Table 2. The induced impacts of export and other final demand to output (times)

	Sector group 1	Sector group 2	Sector group 3
The induced impacts of export to output	2.121	2.271	1.904
The induced impacts of other final demand to output	1.513	1.259	1.700

Source: Author's calculations

Table 3 shows that household spending induce to overall income redistribution the most, and spending from other institutional sectors also spills over to household income the most. Expenditures of the household sector spread the most to income from redistribution of that sector itself, followed by the business sector and finally the State sector. Regular expenditures and transfers of the State sector also spread most strongly to income from redistribution of the household sector, followed by the business sector and finally the State sector. The corporate

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sector's spending on investment and corporate income tax also spills over into household redistributive income, followed by the corporate sector.

These may also be due to the structure of income from production, which accounts for 77% of the total net value added at basic prices of the whole economy (This ratio for industry group 1 is 78%, industry group 2 is 78.% and industry group 3 is 76%).

Table 3. Relationship between expenditure and income of the household, state and business sectors (times)

	Household expenditures	Government expenditures	Investment of enterprises	Total
Household income	0.481	0.395	0.278	1.153
State income	0.160	0.136	0.099	0.394
Enterprise income	0.370	0.309	0.223	0.902
Total	1.011	0.839	0.599	

Source: Author's calculations

Calculation results show that a 30% VAT reduction for service industry groups leads to a direct decrease in the producer price index (PPI) of this industry group by 1.02% and directly affects the producer price index of economy's output is 0.23%.

Moving into the production cycle after the agriculture, forestry, and fisheries sectors and the industry and construction sectors, using inputs from the service sector has reduced prices, causing:

+ Producer price index of the agriculture, forestry and fishery industry decreased by 0.065%
+ Producer price index of the industry and construction sector decreased by 0.070%

The service industry group, which uses its own inputs, reduced prices in the previous round, causes the added value of the service industry group to increase by 0.55%, leading to an increase in GDP of 0.2% and a decrease in the producer price index of 0.05 %.

Note that final consumption of the population is an inverse function of prices, so when prices decrease final consumption increases. Embedding the final consumption vector into the Leontief function gives results on the change in output and GDP (or gross value added). However, reducing VAT for only short time may not be as effective as expected because the production cycle of the agricultural, forestry, fishery and industrial and construction sectors may take longer than 2 months in Vietnam.

Table 4, Change in production value and value added when VAT in the service industry group decrease
s

	Change in output	Change in gross value added (GDP)
Sector group 1	0.09%	0.155%
Sector group 2	0.11%	0.178%
Sector group 3	0.32%	0.550%
Average	**0.15%**	**0.308%**

Source: Author's calculations

Moreover, if direct taxes (personal income tax and corporate income tax) decrease by 30%, it can lead to an increase in savings of the household sector and the business sector, thereby increasing investment by 0.6% and

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leading to to GDP increased by 0.2%

IV. Conclusions

This study shows that the basic I.O model can be applied in a very flexible way with variations extending this model depending on the research purpose.

Research shows that although exports have a strong influence on the production value of all three major sector groups, they have a low influence on factors of added value, especially the lowest diffusion on budget revenue.

Among the three main industry groups, priority should be given to service exports because they best induce to value added. Thus, the export priority policy needs to prioritize services exports (especially tourism activities), followed by exports of agricultural, forestry and fishery products. Exporting industrial products is essentially just exporting for other countries, because the manufacturing sector in Vietnam is basically outsourcing.

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