

The Relationship Between Age Groups and Economics through an Extension of Miyazawa's Demographic-Economic Model

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ABSTRACT: The extension of W. Leontief's I.O system according to the consumption groups and corresponding income was proposed by K. Miyazawa and introduced by Geoffrey J.D. Hewings, Michael Sonis, Moss Madden and Yoshio Kimura (1999) [1] in the book entitled "Understanding and Interpreting Economic Structure". This concept has been applied in economic analysis quite a lot. This study was the first to successfully decompose the final consumption of households according to age groups. The implication of this study (1) shows that the population group that is not yet of working age or over working age is also useful for the economy and the income of other age groups through their consumption and the next implication (2) is that the non-production income of age groups that do not directly participate in production also spreads to the value-added output of the economy. Thus, the income of the working age group is needed not only for themselves but also for their children and parents.

In Miyazawa's demographic-economic model, total income includes indigenous income (income from production) and exogenous income (property income and transfer income), so in that model, the transfer between age groups is considered to be zero. In this paper, the model demographic-economic model of Miyazawa can be extended with indigenous income was included production income and a part of exogenous (income receipted by transferring between age group). This problem is shown in Table 1

KEYWORDS: Age, consumption, demographics, economics, expansion, input, income, spillover, output

I. INTRODUCTION

Since, the Leontief's Input-Output System (1936) [2], this model has been developed and extended in many directions by various researchers. Such as the interregional input-output table originally proposed by Isard (1951) [3]; the multiregional input-output model (MRIO) of Chenery(1954) [4] and Moses (1955) [5], Miller and Blair (1985) [6]; the Social Accounting System (SAM) of Pyatt and Rose (1977, 1985) [7] Pyatt and Round [8]; the demographic-economic Model of Miyazawa (1976) [9], this model was developed in parallel with the Social Accounting Matrix (SAM).

The demographic-economic model was developed by Miyazawa (1976) to analyze the structure of initial distribution and income redistribution based on endogenous and exogenous variables according to the Leontief system criteria. That is, the Leontief system is extended by the final consumption groups of households in the columns and the corresponding income groups in the rows. There have been studies by Nguyen et al (2019) [10] and Bui (2024) [11] applying Miyazawa's demographic-economic model with consumption vectors divided by urban and rural areas.

Basically, total income includes production income and other income (property income and transfer income) in Miyazawa model considered production income is indigenous income and other income as exogenous income. In this paper endogenous income includes production income and a part of other income (income received from transfer between age group). That is expansion Miyazawa ideas on demographic economic model. In Miyazawa's demographic-economic model, non-production income is considered an exogenous variable, so in that model, the transfer between age groups is considered to be nothing (zero). This model can be called the extended Miyazawa demographic-economic model with the existence of non-production income as the transfer between age groups be considered as indigenous income.

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This study divides consumption and income groups by three age groups (group 1: 1-15; group 2: 16-63; group 3: 64 years old and above). The study uses the 2016 and 2022 Vietnam input-output tables with 36 industries (Appendix 1). For data on income and final consumption expenditure: The study uses the results of the household living standards survey in 2016 and 2022 to compile income and expenditure by age structure.

The 2016 input-output table is updated from the 2012 input-output table based on the results of the 2016 enterprise survey and household living standards survey of the General Statistics Office of Vietnam [12]

The 2022 input-output table is updated from the 2019 input-output table based on the results of the 2019 enterprise survey and household living standards survey of the General Statistics Office of Vietnam [13]

Regarding age structure of the population based on "Vietnam Population Forecast for the period 2014-2049 and Vietnam Population Forecast for the period 2019-2069 according to the Average Option" [14]

II. APPROACH

In Miyazawa's demographic-economic model, non-production income is considered an exogenous variable, so in Miyazawa's model, the transfer between age groups is considered to be nothing (zero). In this research, the model was extended with the existence of non-production income as the transfer between age groups. The framework for extending the Miyazawa system according to 3 age groups is described below.

In this framework, final demand includes household final consumption, government final consumption expenditure (G), gross capital formation (I) and exports of goods and services (E). In this study as well as in other economic demographic models, household final demand is divided into appropriate sub-groups based on the data obtained in value added at basic prices including labor income from production (compensation off employees) and gross operating surplus (including depreciation of fixed assets).

Table 1. Framework for extended input – output system by three age groups

			Intermediate demand	Final demand						Gross output
		Intermediate input	A.X	Household final consumption (C)			Remainder of Final Demand (F)			
				Before 15	15-64	After 64	G	I	E	
				c ₁ .M ₁	c ₂ .M ₂	c ₃ .M ₃	F			X
Value added	Incomes	Before 15			V ₁ '		V ₁ ''	V ₁ '''	V ₁ ''''	M ₁ =V ₁ '+V ₁ ''+V ₁ ''' + V ₁ ''''
		15-64	v ₂ .X = V ₂					V ₂ '	V ₂ ''	M ₂ = V ₂ + V ₂ ' + V ₂ ''
		After 64	v ₃ .X = V ₃		V ₃ '		V ₃ ''	V ₃ '''	V ₃ ''''	M ₃ = V ₃ ' + V ₃ '' + V ₃ ''' + V ₃ ''''
	Gross operating surplus									
Gross input			X							

In the above theoretical framework, AX represents the intermediate cost matrix, with A being the direct intermediate cost coefficient matrix and X being the production value vector.

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c₁. M₁ represents the final consumption of the under 15 age group, where c₁ is the coefficient vector final consumption of this age group compared to the total income of that group. Here M₁ is total income of this group; it includes income from transfers by the second age group and from the other sources.

c₂. M₂ represents the final consumption of the 16-63 age group, where c₂ is the final consumption coefficient vector of this age group compared to the total income of that group. Here M₂ includes income from production (V₂), and exogenous income V₂' and V₂''.
 c₃. M₃ represents the final consumption of the age group over 64, where c₃ is the vector of the coefficient of final consumption of this age group compared to the total income of that group. Here M₃ includes income from production (V₃), income from transfers of the 16-63 group (V₃'), income from ownership V₃', income from government transfers (pensions) V₃'' and foreign transfers V₃''

Put: v₁' = V₁'/M₁ and v₃' = V₃'/M₃

From the framework above there are relationships as below:

$$AX + c_1.M_1 + c_2.M_2 + c_3.M_3 + F = X \quad (1)$$

$$v_1'M_1 + (V_1'' + V_1''' + V_1''') = M_1 \quad (2)$$

$$v_2.X + (V_2' + V_2'') = M_2 \quad (3)$$

$$v_3.X + v_3'.M_3 + (V_3'' + V_3''' + V_3''') = M_3 \quad (4)$$

$$\text{Call: } (V_1'' + V_1''' + V_1''') = K_1$$

$$(V_2' + V_2'') = K_2$$

$$(V_3'' + V_3''' + V_3''') = K_3$$

And rewriting the relationships (1), (2), (3), (4) in matrix form we have:

$$\begin{pmatrix} A & c_1 & c_2 & c_3 \\ 0 & 0 & v_1' & 0 \\ v_2 & 0 & 0 & 0 \\ v_3 & 0 & v_3' & 0 \end{pmatrix} * \begin{pmatrix} X \\ M_1 \\ M_2 \\ M_3 \end{pmatrix} + \begin{pmatrix} F \\ K_1 \\ K_2 \\ K_3 \end{pmatrix} = \begin{pmatrix} X \\ M_1 \\ M_2 \\ M_3 \end{pmatrix} \quad (5)$$

And put:

$$B = \begin{pmatrix} A & c_1 & c_2 & c_3 \\ 0 & 0 & v_1' & 0 \\ v_2 & 0 & 0 & 0 \\ v_3 & 0 & v_3' & 0 \end{pmatrix}$$

And put:

$$B_2 = \begin{pmatrix} 0 & v_1' & 0 \\ 0 & 0 & 0 \\ 0 & v_3' & 0 \end{pmatrix}$$

$$c = \begin{pmatrix} c_1 & c_2 & c_3 \end{pmatrix}$$

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$$v = \begin{pmatrix} v_1 \\ v_2 \\ v_3 \end{pmatrix}$$

So we have

$$\begin{pmatrix} X \\ M_1 \\ M_2 \\ M_3 \end{pmatrix} = (I - B)^{-1} \begin{pmatrix} F \\ K_1 \\ K_2 \\ K_3 \end{pmatrix} \quad (6)$$

We can see equation (6) fully satisfied the relationships of the Leontief system

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

$$L = (I - B)^{-1} = \begin{pmatrix} L^A & L^{C_1} & L^{C_2} & L^{C_3} \\ L^{v_1} & & & \\ L^{v_2} & & K & \\ L^{v_3} & & & \end{pmatrix} \quad (7)$$

Based on Sonis and Hewings we have:

$$L^A = (I - (I - A)^{-1} \cdot c \cdot (I - B_2)^{-1} \cdot v)^{-1} \cdot (I - A)^{-1} \quad (8)$$

$$K = (I - (I - B_2)^{-1} \cdot v \cdot (I - A)^{-1} \cdot c)^{-1} \cdot (I - B_2)^{-1} \quad (9)$$

L^A is called the enlarge Leontief inverse matrix including *external multipliers*:

$$\Delta_1 = (I - (I - A)^{-1} \cdot c \cdot (I - B_2)^{-1} \cdot v)^{-1} \quad (10)$$

And internal multipliers $(I - A)^{-1}$

$$L^A = \Delta_1 \cdot (I - A)^{-1} = (I - (I - A)^{-1} \cdot c \cdot (I - B_2)^{-1} \cdot v)^{-1} \cdot (I - A)^{-1} = \Delta_1 \cdot (I - A)^{-1} \quad (11)$$

The extended Leontief inverse matrix L^A is a multiplication between external and internal multipliers, it implies that the output factor of the ordinary Leontief matrix $(I - A)^{-1}$ spreads to income from production (v) which continues to spread to the income redistribution process $(I - B_2)^{-1}$, from there spreads to final consumption of the population (c) and continues spreads towards output.

K is called the extended Miyazawa multipliers consisting of external multipliers:

$$\Delta_2 = (I - (I - B_2)^{-1} \cdot v \cdot (I - A)^{-1} \cdot c)^{-1} \quad (12)$$

And internal multipliers: $(I - B_2)^{-1}$

So, extended Miyazawa multipliers was represented as follows

$$K = (I - (I - B_2)^{-1} \cdot v \cdot (I - A)^{-1} \cdot c)^{-1} \cdot (I - B_2)^{-1} = \Delta_2 \cdot (I - B_2)^{-1} \quad (13)$$

The extended Miyazawa inverse matrix K implies that the redistribution of income between income groups $(I - B_2)^{-1}$ will spread to the final consumption groups of the corresponding réident, from there spreading to output, then continuing to spread to income from production and continuing to spread to income redistribution.

Put: $c = (c_1, c_2, c_3)$ and $M = (M_1, M_2, M_3)$. $v = (v_1, v_2, v_3)$, $L^v = (L^{v_1}, L^{v_2}, L^{v_3})$, $V' = (V_1', V_2', V_3' + V_3'')$ và $L^c = (L^{c_1}, L^{c_2}, L^{c_3})$. Relation (7) is rewritten for brevity as follows:

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$$L = (I - B)^{-1} = \begin{pmatrix} L^A & L^c \\ L^V & K \end{pmatrix} \quad (14)$$

$$L^c = L^A \cdot c \cdot (I - B_2)^{-1} \quad (15)$$

$$L^V = K \cdot v \cdot (I - A)^{-1} \quad (16)$$

From that we have:

$$\begin{bmatrix} \Delta_1 \cdot (I - A)^{-1} & L^A \cdot c \cdot (I - B_2)^{-1} \\ K \cdot v \cdot (I - A)^{-1} & \Delta_2 \cdot (I - B_2)^{-1} \end{bmatrix} * \begin{bmatrix} F \\ V' \end{bmatrix} = \begin{bmatrix} X \\ M \end{bmatrix} \quad (17)$$

Explicit relationship (16):

$$L^A \cdot F + L^A \cdot c \cdot (I - B_2)^{-1} \cdot V' = X \quad (18)$$

$$K \cdot v \cdot (I - A)^{-1} \cdot F + \Delta_2 \cdot (I - B_2)^{-1} \cdot V' = M \quad (19)$$

Equation (18) shows that output (X) depends on final demand ($L^A \cdot F$) and non-production income V' because this income stimulates consumption, which in turn stimulates production.

Equation (19) shows that total income (M) is induced by final demand and non-production income (V').

III. SOME FINDINGS

Table 2 shows that the final consumption of the group under 15 years old and 64 years old and above has a better spillover to output than the consumption of the age group from 16-63 years old, specifically: One unit of final consumption of these groups spreads to output of 1,677 units (group under 15 years old) and 1,688 units (group from 64 years old and above), respectively. Meanwhile, the consumption of the group from 16-63 years old spreads to output of 1,665 units.

The induced impacts of final consumption of age groups to the added value of the economy tends to increase over the years in the period 2016-2022, specifically: In 2016, the final consumption of the age group under 15 years old increased by a unit, which would be induced to the value added of 0.289 units; the final consumption of the age group 16-63 increased by a unit, which would be induced to the value added of 0.312 units, and the consumption of the age group 64 and over would be induced to the value added of 0.271 units. In 2022, the induced impact of final consumption of age groups to the value added of the economy would be 0.453 units, 0.445 units, and 0.461 units, respectively.

In general, the calculation results show that in the period 2016-2022, the final consumption of the age group from 0-15 and over 64 years old induce to the value added of the economy tends to increase gradually, while the spreading to output decreases. Specifically, in 2022, the final consumption of the age group from 0-15 years old induce to the value added increased by 57%, the final consumption of the age group over 64 years old induce to value added increased by 70.2% and final consumption of age group from 16-63 years old increased by 42.3% compared to 2016. (table 2)

Table 2. Induced impacts by final consumption by age group to output and added value in the period 2016-2022 (times)

	0-15			16-63			> 64		
	2016	2019	2022	2016	2019	2022	2016	2019	2022
Output	2.207	1.773	1.677	2.061	1.760	1.665	2.333	1.785	1.688
Value added	0.289	0.429	0.453	0.312	0.422	0.445	0.271	0.435	0.461

Source: Calculated by authors from expansion input output tables

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Tables 3 and 4 show the effect of exogenous income on income redistribution across age groups through the extended Miyazawa multipliers matrix.

The expanded Miyazawa multiplication matrix in table 3 shows the change in final consumption of each age group caused by exogenous income stimulates the redistribution of income among age groups. It shows that final consumption caused by exogenous income increases the income of the 16–63 age group the most, a unit increased in final consumption caused by exogenous income spillovers to the income of this group is 1.487. Interestingly, the consumption of the 16-63 age group caused by exogenous income is 0.380; while the final consumption of the under15 and over64 age group caused by exogenous income spillovers to the income of the 16–63 age group is 0.634 and 0.473, respectively.

One unit of final consumption expenditure of the 16-63 age group caused by exogenous income spillover to income is 0.433 units, of which, spillover to itself is 0.380 units and spillover to income of the under-15 age group is 0.039 units and the over 64 age group is 0.014 units.

It is noteworthy that the final consumption of the under15 and over 64 age group also basically spreads to the income of the 16–63 age group. One unit of final consumption of the under15 age group spreads to the income of the 16–63 age group by 0.634 units, while the spread to itself income is 0.066 units and the spread to the income of the over64 age group is 0.034 units.

Another thing worth noting is that the consumption of the over 64 age group spills over to the income of the under15 age group more than it spills over to their own income (0.050 vs. 0.032).

Interestingly, the final consumption of the 16-63 age group caused by exogenous income is 0.380; while the final consumption of the under15 and over64 age group caused by exogenous income spillovers to the income of the 16–63 age group is 0.634 and 0.473, respectively.

Table 3: Expansion Miyazawa multipliers, 2016 (times)

		Final consumption			
		0-15	16-63	> 64	Total
Income	0-15	0.066	0.039	0.050	0.155
	16-63	0.634	0.380	0.473	1.487
	> 64	0.034	0.014	0.032	0.081
	Total	0.734	0.433	0.555	

Source: Calculated by authors from expansion input output tables, 2016

The extended Miyazawa factor in 2022 in Table 4 shows that the spillover trend of exogenous income among age groups has not changed much, but the spillover level of final consumption caused by exogenous income to the income of age groups has decreased compared to the period represented by the input output table in 2016.

Table 4: Expansion Miyazawa multipliers, 2022 (times)

		Final consumption			
		0-15	16-63	> 64	Total
Income	0-15	0.059	0.035	0.035	0.129
	16-63	0.555	0.332	0.331	1.218

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>64	0.038	0.019	0.025	0.083
Total	0.652	0.386	0.392	

Source: Calculated by authors from expansion input output tables, 2022

IV. CONCLUSION AND POLICY IMPLICATIONS

The study attempts to provide some results that can serve as a basis for developing macro policies and strategies that contribute to better adapting to the relatively rapid population change in Vietnam in recent times, especially the rate of population aging. Specifically as follows:

The findings also indicate that consumption by the population aged over 64 is increasingly contributing to value-added spillovers within the economy. Consumption by children under the age of 15 ranks second, while the working-age population has the lowest spillover effect. This shows that the over 64 age group tends to contribute more and more to the added value of the economy. Although the income and expenditure of this group account for a relatively small share of total household income and spending, the spillover effects from final consumption to the income of the over-64 age group are often the highest and have been increasing over the years. This reflects a societal trend in which post-retirement individuals are actively engaging in agricultural activities such as crop cultivation and livestock raising. With about 70% of the elderly living in rural areas, and over one-third still needing to work to earn a living, it is necessary to create a supportive environment for the elderly to continue to participate in the labor force and do paid work. In particular, generating job opportunities for the elderly in the agricultural sector is a key solution to helping them secure their livelihoods and exercise their right to live independently - especially among low-income groups, the poor and single elderly, and those residing in particularly disadvantaged communes. At the same time, final consumption by the 0–15 age group—through expenditures on healthcare, education, and care-related goods and services—also contributes to stimulating production, thereby generating increasingly significant spillover effects on value added across the economy over time. This suggests that the government may consider designing flexible and demographically responsive welfare policies to optimize the economic spillover efficiency of age-specific consumption, while simultaneously ensuring social equity and fiscal sustainability.

The research results show that in the period 2016 - 2022, final consumption of all age groups tends to spread less to output and spread more to value added. In particular, final consumption of the age group 0-15 and the group aged 64 and over (referred to as the dependent group) has a better spread to the value added of the economy, although this is not the main labor group of the economy. However, this is also a burden and pressure on the main labor group in terms of family responsibilities (raising children and caring for and supporting parents). In addition, consumption of the two dependent groups also stimulates the largest exogenous income. This implies the burden on people of working age to earn income, accumulate, and create non-production income in the next period. This group is not only responsible for maintaining their current life, covering expenses for themselves and their families, but also has to accumulate finances for the next stages (such as saving for retirement, investing in children's education, and caring for elderly parents). Therefore, they are the group that has to shoulder a "double burden" because they have to ensure their current life while preparing for the future. Solving this burden requires comprehensive solutions. These may include measures such as "increasing wages, reducing working hours, and providing training to enhance labor productivity...". In addition, policies such as extending the retirement age, promoting employment opportunities for older workers in selected sectors, and offering dependent deductions under the personal income tax regime for working individuals should also be considered.

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APPENDIX I: 36 INDUSTRIES SURVEYED IN THE MODEL

Numerical order	Sectors
1	Annual crop products
2	Perennial crop products
3	Livestock products
4	Agricultural services
5	Other agricultural products
6	Forest planting and maintenance
7	Timber harvesting
8	Other forest products; forest products
9	Forestry services
10	Aquaculture products
11	Aquaculture products
12	Exploitation products
13	Meat and meat products
14	Processed and preserved aquatic and aquatic products
15	Processed vegetables
16	Milk and dairy products

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17	Milk and flour products
18	Animal feed, poultry and aquatic products
19	Wood and bamboo products
20	Fertilizers and nitrogen compounds
21	Pesticides and other chemical products used in agriculture
22	Other processed and manufactured products
23	Electricity, gas, hot water, steam and air conditioning
24	Natural water harvesting
25	Construction products
26	Wholesale and retail services; Car, motorbike, scooter and other motor vehicle repair services
27	Warehousing and transportation services
28	Accommodation and catering services
29	Information and communication services
30	Banking and insurance financial services
31	Real estate business services
32	Other professional, scientific and technological services
33	Education and training services
34	Health and social assistance services
35	Arts, entertainment and recreation services
36	Other services



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