

## Sufficiency Economy Matrix multiplier analysis and optimization: The case of Mukdahan, Thailand

Jintanee Jintranun<sup>1</sup>, Peter Calkins<sup>2</sup>, Songsak Sriboonchitta<sup>3</sup>

<sup>1</sup>*School of Management, Walailak University  
E-mail: jintanee@hotmail.com*

<sup>2</sup>*Faculty of Economics, Chiang Mai University  
E-mail: peter\_calkins2004@yahoo.com*

<sup>3</sup>*Faculty of Economics, Chiang Mai University  
E-mail: songsakecon@gmail.com*

### ABSTRACT

This paper has used Sufficiency Economy Matrix multiplier and optimization analyses to estimate the impacts of the East West Economic Corridor on economic growth, poverty reduction and the implementation of the sufficiency economy philosophy in Mukdahan province, Thailand. We employed both the standard multiplier model and linear programming optimizations to explore provincial plans increasingly constrained by resources, environmental and social planning objectives. The results reveal that the optimized SAM, ESAM and SEM lead to significantly different plans for economic development and poverty reduction in Mukdahan province. The EWEC and tourism exert high and widespread multiplier effects on marketing, communication, and financial services in Mukdahan, while charitable donations and direct transfers to poor households constitute the most effective sufficiency economy social strategy. Road construction, *wats*, and employment creation in border tourism should optimally receive increased aggregate investment; while government programs should be substantially reduced. The results give further support to the importance of studying and applying the King's Sufficiency Economy at the provincial and national level in Thailand and around the world.

*Keywords:* Sufficiency Economy Matrix, multiplier analysis, linear programming, Mukdahan, Thailand

*JEL Classification:* R15, I38, Q01

## 1. Introduction

Social accounting matrices or **SAMs** are frequently used in studies of developing economies because economists and planners believe they yield accurate value-added, employment, and household income multipliers for the formulation of development plans. But such multiplier analyses suffer from three shortcomings: individual multipliers cannot yield an integrated plan under general equilibrium, they are not realistically constrained by natural resources, and they fail to take account of either social objectives or development philosophies. This paper will illustrate the use of optimizable Sufficiency Economy Matrices (**SEMs**) as a tool for overcoming these shortcomings. It will do so for the case of Mukdahan province, Thailand, which has a greater-than-average potential for both balanced economic growth and rapid development because it lies on the East-West Economic Corridor (EWEC) designed to interconnect and stimulate the national economies of Southeast Asia.

The EWEC is a multi-sector economic development project that focuses on the linkages among transportation, economic development, tourism, trade, employment creation, and poverty reduction. Its goal is to develop a highly efficient transport system which will allow goods and people to move around the Greater Mekong Subregion (GMS) without significant impediment, excessive cost or major delay. The EWEC's central component is a 1,450-km long road connecting two seaports: Da Nang in Vietnam with Mawlamyine in Myanmar by cutting across Savannakhet province in southern Laos and western, northern, and northeastern Thailand. Major ancillary projects worth \$2.5 billion include the construction of highway No.9, and the Hai Wan Tunnel.

The development potential of Mukdahan province stands out along this pathway. First, it benefits from a mega transportation investment project, the Thai-Laos Friendship Bridge 2 begun in December, 2003 and opened on December 20, 2007 links the sister provincial capitals of Mukdahan in northeastern Thailand and Savannakhet in Southern Laos. As a border node, Mukdahan also benefits from transportation infrastructures that improve its economic potential to become a major gateway of trade and investment into Indochina and a pole of tourism and finance in the region. These include the Construct Bypass High Way No.1 8 km, the Mukdahan – Comechade 35-km road, the Comesoi – Luengnokta 21-km road and the Maesod – Mukdahan and Leamchabung – Mukdahan highways.



Figure 1 East West Economic Corridor map  
Source: <http://www.adb.org/GMS/Economic-Corr...background.asp>

Despite Mukdahan’s favourable transportation position and mega investments from the EWEC, it remains one of the poorest provinces in Thailand. In 2008, Mukdahan had the third lowest gross provincial product (GPP) of Thailand’s 76 provinces, following Maehongson and Amnatcharearn; and the 15<sup>th</sup> lowest GPP per capita (up, however, from 7<sup>th</sup> in 2005). In 2006, 21-30% of the population was poor. The question becomes to what extent improved roads could catalyse reductions in the incidence of poverty. The alternative would be to support local community institutions such as Buddhist *wats* and NGOs. In this regard, Mukdahan’s religious institutions and minority tribes supply strong bonding social capital.<sup>1</sup>

<sup>1</sup> *Bonding* social capital is the value of close, positive relationships with those of one’s own ethnic or locational group. As such, it is considered to be “horizontal.” *Bridging* social capital is the value of positive, collaborative relationships extended to other groups in the greater society, frequently those with greater economic or social influence. As such, it is considered to be “vertical.” In an application to India, Varshney (2001) found that bridging social capital served as an agent of peace, bridge-building and tension-management among previously unconnected communities of differing ethnic origin. He also determined that to a certain extent, intra-ethnic policing (enhanced bonding) may lead to the same positive results as interethnic engagement (bridging).

The economic structure of Mukdahan (Figure 2) is similar to that of the Northeast region as a whole. Although the GPP growth rate rose to 3.4% in 2008 from 2.4% in 2004, it still lagged behind Northeastern gross regional product (GRP) overall growth rates of 5.9% in 2008 and 3.68% in 2005 (Table 1). Agricultural growth has fallen behind that of the industrial and service sectors, including tourism. Lying as it does on the Mekong River between two countries (Thailand and Laos), and within 10 kilometers of its sister city Savannakhet, Mukdahan has the potential to become the hub for package tours by foreigners and country nationals alike. Travelers must spend four hours or overnight in Mukdahan to arrange visas and other documents for their onward travel.

### The scientific problem

To our knowledge, few or no studies have explicitly compared government-sponsored infrastructural investments (such as bridges, roads, market facilities) with social and religious institutions as sources of economic growth, poverty alleviation and improved income distribution. There are three main channels to redistribute income: a) voluntary and government mechanisms, b) direct transfers between persons or households and c) indirect transfer through institutions such as central/local government, NGOs, international organizations and religious institutions. Each channel generates different transfer costs and target outreach effects.

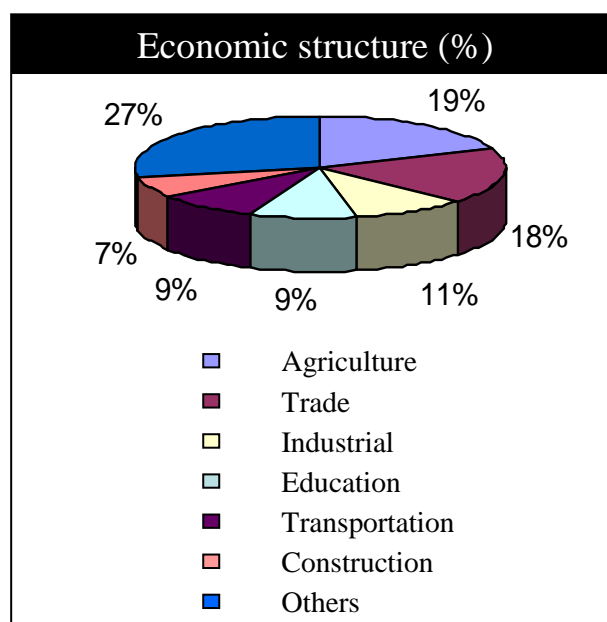


Figure 2. Mukdahan provincial economic structure<sup>2</sup> Source: 1

If the leaders of a poor province in a developing country could access accurate information on the multiplier effects of a major new international road and the strengthening of non-government institutions, optimal policies could be identified to minimize the costs and maximize the benefits of programs for social improvement.

<sup>2</sup> Calculated from 16 economics sectors. Others are composed of 10 sectors: 1) Fishing 2) Mining and quarrying 3) Electricity, gas and water supply 4) Hotels and restaurants 5) Financial intermediation 6) Real estate, renting and business activities 7) Public administration and defence 8) Health and social work 9) Other community, social and personal service activities, and 10) Private households with employed person

**Table 1. Economic situation in Mukdahan**

Year	Mukdahan GPP at market prices	Mukdahan GPP at constant 1988 prices	Mukdahan GPP/cap (Baht) at constant prices	Mukdahan Population (1,000 persons)	Thailand /cap (Baht) Thailand at constant prices	NE regional GRP/cap (Baht) at constant prices
2001	7,965	4,648	14,303	325	47,675	14,358
2002	8,654	5,063	15,426	328	50,283	15,522
2003	9,161	5,231	15,816	331	52,810	16,518
2004	9,818	5,277	15,857	333	54,051	16,607
2005	10,163	5,106	15,260	335	54,741	16,159
2006	11,571	5,346	15,916	336	55,310	16,707
2007	12,863	5,748	17,020	338	57,716	17,948
2008	13,875	5,842	17,198	340	57,477	18,091
<i>Increase</i>						
2008-2001	74%	26%	20%	5%	21%	26%

Source: Calculations based on data from [www.nesdb.go.th](http://www.nesdb.go.th)

## 2. Research objective

The overall objective of this research is to evaluate to what extent the EWEC project could both reduce relative and absolute poverty and actively serve to implement the sufficiency economy philosophy at the provincial level of Mukdahan. We shall therefore sort, measure, and compare the roles of infrastructure, markets, government, and non-government and charitable institutions in one of the poorest areas of Thailand through both

1) *multiplier analysis* to quantify the direct and  $n^{\text{th}}$  round impacts on economic development, marketization, employment generation, and relative and absolute poverty of individual activities touching the new road, cross-border tourism, the functioning of Buddhist temples.

2) *linear programming optimization* to measure the current, potential economic, potential environmental, and potential sufficiency economy impacts of the new road, cross-border tourism and the functioning of Buddhist temples with a general equilibrium context.

For both types of analysis, a traditional SAM, an environmental SAM (or ESAM) and a sufficiency economy matrix (SEM) inspired by King of Thailand's Sufficiency Economy Philosophy will be employed. Once the two analyses are completed, we shall determine whether or not the policy implications of the two approaches converge upon the same economic activities, target institutions, and household behaviours to be encouraged. If they do not, we shall argue that the resource and policy constraints of approach 2 give more realistic results to policy makers than the unconstrained multipliers of approach 1.

### 3. Literature review

In Thailand, several SAM studies have been realized at the national level. Li (2002) constructed a social accounting matrix for Thailand of two types: an aggregate or “macro” SAM and a disaggregated or “micro” SAM. The micro SAM in its modified version was obtained from the Thai Development Research Institute (TDRI). The other previous Thai SAMs are due to Ammaranan and Chivakriangkrai (1980), Tinakorn and Sussangkarn (1999), TDRI (2001), Saebae (2001), and Poonsawat (2008),

Currently, there are no SAM studies at the provincial level in Thailand. For Mukdahan province, there does exist an interregional input-output table (Sim et al 2007) for the cross border sister economies of Mukdahan and Savannaket.

### 4. Research methods

#### Standard multiplier model

To develop a multiplier model, one first specifies which accounts are to be treated as exogenous and endogenous (Pyatt and Round)<sup>3</sup>. Exogenous sectors are those expected to inject investment capital; while the remaining, endogenous accounts are the sectors upon which that capital is expected to have direct and *n*th round effects. Each SAM specifies different choices as to which economic actors are to be included in each category. In the case of Mukdahan, production and sales activities, factor payments, households, and businesses are defined to be endogenous accounts; while foreign households, multinational firms, governments, and the Rest of Thailand or World accounts are treated as exogenous.

The next step is to adjust the matrix of endogenous transactions by dividing each element of each column of by its column sum **T** to define the **A** matrix of input-output technical coefficients:

$$\mathbf{T} = \mathbf{A}\mathbf{y} \quad [1]$$

**X** is the vector of exogenous injections that affect the matrix **Y** of total value added:

$$\mathbf{Y} = \mathbf{A}\mathbf{Y} + \mathbf{X} \quad [2]$$

We may then rewrite the model to isolate the impacts  $(\mathbf{I} - \mathbf{A})^{-1}$  of external injections **X** upon the value of total net value added **Y**:

$$\mathbf{Y} = (\mathbf{I} - \mathbf{A})^{-1}\mathbf{X} = \mathbf{M}_a\mathbf{X} \quad [3],$$

where  $\mathbf{M}_a$  is the SAM multiplier matrix, **I** is an Identity matrix, and  $(\mathbf{I} - \mathbf{A})^{-1}$  is the inverse of the matrix  $(\mathbf{I} - \mathbf{A})$ .

#### Sufficiency economy matrix multiplier analysis

The above data structure and analysis will be further expanded to include charitable institutions (*wats* and NGOs) and local government in the endogenous accounts, as well as central government in the exogenous accounts. Since none of the fifteen NGOs contacted by telephone were in a position to separate out the provincial level data (in the case of large NGOs) or give accurate information (in the case of small NGOs), the 2006 NSO secondary data base involving NGOs for all of Thailand was consulted.

Our focus on poverty and income distribution then led us to disaggregate factor accounts by occupation; and household accounts by income level (5 quintiles) in each of

<sup>3</sup> Pyatt, Graham and Jeffery I. Round (1979). Accounting and Fixed Price Multipliers.

three geographical areas (rural, semi-urban, and urban) radiating out from Mukdahan city center, for a total of 15 income/location categories of households. These accounts were labeled RHH1..RHH5, SHH1S5, and UHH1 UHH5, where **1** signified the poorest quintile in each zone. This research will also construct<sup>4</sup> an environmental **ESAM** and a sufficiency economy **SEM** in parallel with the standard **SAMs** as used in other countries. An **ESAM** involves adding a pollution constraint to reflect the environmental damage associated with certain production, marketing and transport activities. The definition of a **SEM** is drawn from the principles of the King of Thailand's sufficiency economy philosophy: *knowledge, ethics, reasonableness, self-immunization, and moderation* in households and private and public enterprises, all of which principles are in turn subjected to *balance*. "Sufficiency" or "moderation," the central concept, is reflected in two ways. The first is estimation of the absolute and relative income multipliers of each activity on the poorest household categories; the second is optimization of per capita value added given all the above constraints.

### Linear Programming

To determine the optimal plan under each of the three formulations (**SAM**, **ESAM**, **SEM**) we embedded the non-inversed **I-A** matrix of expression [3] into linear programs subject to increasingly numerous constraints. Any linear programming model is composed of an objective function, parameters (assumed to be linear) and constraint functions with equalities or inequalities. The linear program for the full **SEM** takes the following form:

$$\text{Max } \mathbf{V} = \mathbf{v} * \mathbf{x} \quad [4]$$

$$\text{s.t. } \mathbf{I-A} \geq \mathbf{0} \quad [5]$$

$$\mathbf{r} \leq \mathbf{b} \quad [6]$$

$$\mathbf{e} \leq \mathbf{c} \quad [7]$$

$$\mathbf{s} \geq \mathbf{d} \quad [8]$$

$$\mathbf{x} \geq \mathbf{0}. \quad [9]$$

where **V** = total township value added

**v** = value added for each activity

**x** = the output level of each activity

**r** = resource constraints

**e** = pollution and other environmental constraints

**s** = sufficiency economy constraints

**b, c, d** = maximum or minimum permissible level of each constraint

The **SAM** optimization is subject only to the **r** constraints, the **ESAM** to the **r** plus **e** constraints, and the full **SEM** to the **r** plus **e** and **s** constraints.

### 5. Mukdahan SAM Structure

The full Mukdahan **SEM** (and its subset **SAM** and **ESAM** formulations) will be composed of 61 production and sales activities, four social welfare activities, three endogenous institutions, seven production factors, 15 household categories (i.e., five quintiles

<sup>4</sup> Adaptation "Author," "Training for Ph.D. students in GMS SAM[1].xls" for training Ph.D. student in Research methodology for economists course.

in each of three distance Mukdahan), and connections with six exogenous sectors outside of Mukdahan (Table 2).

**Table 2.** Mukdahan SEM structure

<i>Number*</i>	Name	<i>Number</i>	Name
	<b>Production and sales activities</b>		<b>Production and sales activities cont.</b>
1	Rice	50	House servants
2	vegetable	51	Agricultural service
3	Fruit	52	Marketing raw agricultural
4	Other crop	53	Marketing of agro-industrial
5	Beef and pork	54	Marketing industrial
6	Chicken and duck	55	Marketing services
7	Fish and fresh water shirmp	56	Lottery tickets and gambling
8	Forestry and logging	57	Religious activities expenditure
9	Mining		<b>Social welfare activities</b>
10	Rice mill	58	Direct donations
11	Flour	59	Educational donations
12	Sugar	60	Other and environmental donations
13	Butcher beef and pork	61	Social transfers
14	Meat and poultry		Endogenous institutions
15	Dairy products	62	Local public admin
16	Canned products	63	Local government
17	Noodles	71	Enterprises
18	Tobacco, alcoholic		<b>Factors of production</b>
19	Other food and beverage	64	Agricultural labor
20	Costume and textile	65	Merchant labor
21	Shoes and repair	66	Service labor
	Handicraft, gift and souvenirs and		
22	silk	67	Industrial labor
23	Wooden products	68	Other labor
24	Reading activities	69	Capital
25	Retail for commuting (car fuel)	70	Buildings and land
26	Cosmetics		<b>Households by urbanity and quintile</b>
27	Retail and wholesale vehicles	72	RHH1
28	Electrical appliances	73	RHH2
29	Furnitures	74	RHH3
30	Other products	75	RHH4
31	Electricity and water supply	76	RHH5
	Chemical Product and plastic		
32	packaging	77	SHH1
33	Fertilizer and pesticide	78	SHH2
	Repair/maintenance machine and		
34	dwelling	79	SHH3
35	Construction service	80	SHH4
36	Road construction service	81	SHH5
37	Local transportation service	82	UHH1
38	Vehicle repair and maintenance	83	UHH2
39	Communication	84	UHH3
40	Bank and financial	85	UHH4
41	Insurance	86	UHH5
42	Health care and medicine		<b>Exogenous institutions</b>
43	Recreation and sports	87	NGOs*
44	Massage	88	Public Admin
45	Other activities (spa, coiffure)	89	Other government service
46	Education	90	Central government
47	Special occasion travel and tours	91	Rest of Thailand (ROTH)
48	Accommodation	92	Rest of world (ROW)
49	Laundry	93	Other expenditure

*\*These numbers will be used throughout the remainder of this paper \*\* possibly endogenous*



Mukdahan activities may thus be divided into production, sales and marketing, and private and government services. Details within each group are based on the secondary data contained in *Mukdahan GPP123,2009* among which we further disaggregated some activities of particular interest for hypothesis testing. Production activities were those generated within Mukdahan only, i.e., not including middle men, which were then disaggregated into marketing and retailing activities. Household data were collected by questionnaire and interview, while religious institutions and NGOs were sent questionnaires by mail. Since the response rate (10%) was small, we adjusted their coefficients with non-government organization data collected by the National Statistical Organization (NSO) at the national level that. Local and central government data were obtained from the provincial fiscal office database. For the Rest of Thailand and the Rest of the World, we employed the 2006 I/O matrix adjusted by the growth rate to 2009 in the cells of imports and exports.

### **Testable hypotheses**

Based on the above review of literature, theoretical framework and policy requirements, we formulated a set of eight (8) hypotheses for testing in the current study:

*H1:* The EWEC exerts high and widespread multiplier effects on marketing, communication, and financial services in Mukdahan.

*H2:* Tourism exerts high and widespread multiplier effects on marketing and financial services in Mukdahan.

*H3:* The overall value-added, employment, and household income multipliers of EWEC transportation and tourism rank substantially above those of other economic activities in Mukdahan.

*H4:* Religious institutions exert multiplier effects that are more effective in reducing poverty than those of direction donations, NGOs, or government transfers.

*H5:* Charitable donations and direct transfers to poor households constitute the most effective sufficiency economy social strategy.

*H6:* Road construction, *wats*, and employment creation in border tourism should optimally receive increased aggregate investment; while government programs should be substantially reduced.

*H7:* The optimized SAM, ESAM and SEM lead to significantly different plans for economic development and poverty reduction in Mukdahan province, giving further support to the importance of studying and applying the King's Sufficiency Economy.

*H8:* The SAM, ESAM and SEM optimizations, being realistically constrained by resources, environmental and social planning objectives, give substantially different and logically superior guidelines for private entrepreneurship and public policy than standard, unconstrained multiplier analysis.

Hypotheses H1 through H5 will be tested through standard multiplier analysis, while Hypotheses H6 and H7 will be tested through linear programming optimization.

## 6. Empirical results

### Current sufficiency economy situation in Mukdahan province

Tables 3 through 5 provide essential preliminary information on the current state of the Mukdahan economy as a background for the subsequent testing of our eight research hypotheses. First or all, to accentuate the challenges to sufficiency economy application in Mukdahan, table 3 details the unemployment risk and pollution score of each activity.

**Table 3.** Unemployment risk and pollution score

Num ber	Activity	Unemployment (K-L intensity) balance, ethics		Pollution (reasonableness)		Avg. rank
		Score	Rank	Score	Rank	
9	Mining	4.332	4	0.307	3	4
15	Dairy products	3.609	5	0.150	4	5
33	Fertilizer and pesticide	3.193	9	0.319	2	6
17	Noodles	3.476	7	0.022	15	11
12	Sugar	2.939	11	0.037	13	12
	Chemical Product and plastic					
32	packaging	16.944	2	0.011	24	13
23	Wooden products	3.323	8	0.009	25	17
6	Chicken and duck	1.890	25	0.055	10	18
40	Bank and financial	100.836	1	0.002	34	18
3	Fruit	1.376	29	0.063	9	19
8	Forestry and logging	1.688	26	0.025	14	20
7	Fish and fresh water shrimp	0.321	38	0.125	5	22
4	Other crop	0.514	35	0.087	8	22
51	Agricultural service	6.021	3	0.000	42	23
5	Beef and pork	0.243	40	0.121	6	23
21	Shoes and repair	1.587	27	0.017	21	24
26	Cosmetics	2.252	22	0.008	26	24
54	Marketing industrial	2.421	16	0.004	32	24
37	Local transportation service	0.000	48	0.462	1	25
41	Insurance	2.679	12	0.001	37	25
49	Laundry	0.525	34	0.021	16	25
53	Marketing of agro-industrial	3.530	6	0.000	46	26
24	Reading activities	2.963	10	0.000	43	27
1	Rice	0.000	47	0.107	7	27
44	Massage	0.484	37	0.020	17	27
36	Road construction service	1.920	24	0.004	30	27
35	Construction service	0.543	33	0.015	22	28
48	Accommodation	0.734	32	0.014	23	28
10	Rice mill	1.527	28	0.007	28	28
14	Meat and poultry	2.283	19	0.001	38	29
50	House servants	0.001	46	0.045	12	29
2	Vegetable	0.242	41	0.019	18	30
29	Furniture	0.000	49	0.047	11	30
	Repair/maintenance machine and					
34	dwelling	1.008	31	0.007	29	30
25	Retail commuting (car fuel)	2.461	13	0.000	47	30
16	Canned products	2.283	20	0.000	41	31
27	Retail and wholesale vehicles	2.453	14	0.000	48	31
28	Electrical appliances	2.447	15	0.000	49	32
13	Butcher beef and pork	2.283	21	0.000	44	33
55	Marketing services	2.414	17	0.000	50	34
43	Recreation and sports	0.000	50	0.018	19	35

Num ber	Activity	Unemployment (K-L intensity) <i>balance</i> , <i>ethics</i>		Pollution ( <i>reasonableness</i> )		Avg. rank
		Score	Rank	Score	Rank	
19	Other food and beverage	2.383	18	0.000	51	35
31	Electricity and water supply	0.000	51	0.017	20	36
42	Health care and medicine	0.019	44	0.004	31	38
20	Costume and textile	0.237	42	0.003	33	38
45	Other activities (spa, hairdress)	0.506	36	0.000	39	38
38	Vehicle repair and maintenance	2.024	23	0.000	52	38
22	Handicraft, gift and souvenirs and silk	0.000	52	0.007	27	40
46	Education	0.021	43	0.000	40	42
11	Flour	1.185	30	0.000	53	42
52	Marketing raw agricultural	0.255	39	0.000	45	42
39	Communication	0.000	53	0.001	35	44
30	Other products	0.000	54	0.001	36	45
18	Tobacco, alcoholic	0.004	45	0.000	54	50

Source: Calculations based on data from Mukdahan Social Accounting Matrix

Unemployment risk is computed from the capital-labor intensity that threatens Sufficiency Economy *balance* in each production, sales and service activity. The financial sector has the highest capital intensity, followed by chemical products, agricultural services, and mining. In contrast, rice production and other agriculture activities are the most *self-reliant* productions in terms of local labour.

Nor is pollution *reasonable* in the environment dimension (last column of Table 3). The results show that local transportation and service, fertilizer and pesticide, mining, and agricultural services are the most polluting, while electrical appliances and marketing services are the least. Local transportation leads to high pollution because renovated old motorbikes and cars employed in local transport burn fuel in a dirty fashion. Within agriculture, fishponds, cattle-raising and rice production had the highest scores because they rely intensively on machinery. There is thus a potential conflict within rice production between the sufficiency economy principles of *reasonableness* vs. *balance* and *ethics*.

Table 4 explores current household behavior for both *reasonableness* and the remaining sufficiency economy concepts of *knowledge*, *self-immunization*, and *ethical* sharing. The rural middle (RHH3) and poorest (RHH1) household classes pay the highest share for educational expenditures, suggesting that unequal access to educational services may be partly attributable to inadequate transportation. Similarly, rural classes 3 and 4 have the highest health expenditure budget shares, reflecting high transportation costs to the central government hospital or private hospitals in the urban area. "Recreational" gambling is both *unreasonable* in terms of expected gains but also *unethical* in terms of the use of household financial resources. There exist many kinds of illegal lottery; twice per month (both from Thailand and Laos) and twice per day (from SET index close at noon and afternoon). Access to this market is easy for all household categories; only middle to upper class urban households have been wise enough to abstain.

**Table 4.** Household expenditure score

Region-quintile category	(1)	(2) Health expenditure	(3) Wat and community expenditure	(4) Gambling expenditure	SE behavior: 1+2+3 - 4	
	Educational expenditure <i>Knowledge</i>	<i>Self-immunization</i>	<i>Ethics and sharing</i>	<i>Reasonableness, Ethics</i>	Score	Rank
RHH3	0.156	0.035	0.016	0.003	0.204	1
RHH1	0.107	0.008	0.056	0.006	0.164	2
SHH4	0.131	0.006	0.035	0.008	0.164	3
SHH3	0.093	0.011	0.053	0.006	0.150	4
SHH2	0.081	0.012	0.056	0.008	0.141	5
RHH2	0.096	0.004	0.044	0.005	0.140	6
SHH1	0.072	0.008	0.060	0.006	0.133	7
UHH2	0.051	0.005	0.059	0.005	0.111	8
SHH5	0.065	0.010	0.033	0.006	0.102	9
RHH4	0.057	0.021	0.022	0.008	0.092	10
UHH1	0.020	0.020	0.039	0.006	0.073	11
RHH5	0.057	0.003	0.012	0.004	0.068	12
UHH3	0.008	0.004	0.048	0.000	0.060	13
UHH4	0.004	0.001	0.026	0.003	0.028	14
UHH5	0.002	0.001	0.018	0.001	0.020	15

The *wat* and community expenditure score (*ethical sharing*) shows that, charitable giving in Mukdahan unfortunately follows Engel's law for food: its share decreases with rising income. The lowest giving share is by the richest rural quintile (RHH5); while the highest is in the semi-urban area, where community bonding relationships are strong and access to temples is convenient. The last column of Table 4 reveals that middle class households in rural areas (RHH3) have the most exemplary sufficiency economy behavior overall, followed by rural poor and semi-urban rich households. This result may help government to efficiently target awareness-raising programs by zone and income level.

As a measure of *self-immunization* against social unrest, Table 5 reports the share of income from each production factor received by the two lowest (1, 2) quintiles in each zone divided by the total income from that factor across all 15 household categories of Mukdahan.

**Table 5.** Income to poor (self-immunization)

Production factor	Income to poor households (m baht)	Share of poor household income
Agricultural labor	4,258.6	37.89%
Merchant labor	399.0	6.88%
Service labor	97.2	2.94%
Industrial labor	127.3	4.67%
Other labor	2.3	3.95%
Capital	226.3	2.00%
Buildings and land	24.9	7.46%

*Source: Calculations based on data from Mukdahan Social Accounting Matrix*

Poor people receive the highest share of income from agricultural labour and the lowest from service and industrial labour. Government pro-poor programs could therefore focus upon enhancing farm labor efficiency and productivity to improve agriculture labor income. Moreover, government could make complementary investments in land quality improvement since these also bring the second-highest share of income to the poor. In contrast, budget injections into service or industry would have only a minor effect on poverty reduction.

## Hypothesis testing

*H1: The EWEC exerts high and widespread multiplier effects on marketing, communication, and financial services in Mukdahan.*

The decomposition of the direct and indirect income multipliers from various branches of the transportation sector (Table 6) reflects the pervasive power of the EWEC. Local transportation service, vehicle repair and maintenance, and road construction services create the greatest transportation impacts (1.07, 1.043, and 1.001, respectively) since they are composed of both direct and indirect effects. For example, 1 million baht invested in road construction services can yield 1.001 baht to aggregate road construction demand itself; but also 606,000 baht to industrial product marketing. Meanwhile, local transportation investment yields 1.019 m for itself and 519,000 in additional commuting fuel demand. Communication impacts rank 9<sup>th</sup> in Table 6 at a level of 87,000 baht. Finally, the demand for banking and financial institutions increases by 34,000 baht, implying that approximately 7-8 % of EWEC investment serves to expand financial institutions. We therefore cannot reject hypothesis 1.

**Table 6.** Decomposition of direct and indirect impacts of transportation income multipliers on marketing, communication, and financial activities

Number	Activity impacted by transportation	Local transport service	Vehicle repair/maintenance	Road construction service	Total transportation multiplier	Rank
37	Local transportation service	<b>1.019</b>	0.000	0.052	1.071	1
38	Vehicle repair and maintenance	0.036	<b>1.000</b>	0.007	1.043	2
36	Road construction service	0.000	0.000	<b>1.001</b>	1.001	3
54	Industrial marketing	0.056	0.003	0.606	0.665	4
25	Retail for commuting expenditures (car fuel)	0.471	0.000	0.048	0.519	5
55	Marketing services	0.387	0.002	0.075	0.464	6
31	Electricity and water supply	0.012	0.000	0.238	0.250	7
27	Retail and wholesale vehicles	0.052	0.050	0.041	0.143	8
39	Communication	0.055	0.000	0.032	0.087	9
9	Mining	0.000	0.000	0.073	0.073	10
19	Other food and beverage	0.046	0.000	0.013	0.059	11
52	Marketing raw agricultural	0.021	0.002	0.029	0.052	12
41	Insurance	0.032	0.000	0.007	0.039	13
62	Local public admin	0.006	0.001	0.031	0.038	14
40	Bank and financial	0.015	0.001	0.018	0.034	15
46	Educational	0.013	0.001	0.019	0.033	16
28	Electrical appliances	0.002	0.014	0.015	0.031	17
53	Marketing of agro-industrial	0.012	0.001	0.018	0.031	18
63	Local government	0.007	0.001	0.021	0.029	19
1	Rice	0.016	0.000	0.004	0.02	20
47	Special occasion travel and tours	0.016	0.000	0.003	0.019	21

*Source: Calculations based on data from Mukdahan Social Accounting Matrix*

*H2: Tourism exerts high and widespread multiplier effects on marketing and financial services in Mukdahan.*

The tourism sector is one visible potential offshoot of implementing the EWEC. The multiplier effects of tourism (Table 7) are calculated from the summation of special occasion travel and tours, accommodation, and other activities such as spas and coiffure.

**Table 7.** Decomposition of direct and indirect impacts of tourism income multipliers on marketing and financial activities

No.	Activity impacted by tourism	Special occasion travel/tours	Other activities (spa, coiffure)	Accommodation	Total tourism multiplier	Rank
47	Special occasion travel and tours	<b>1.004</b>	0.003	0.003	1.010	1
45	Other activities (spa, coiffure)	0.001	<b>1.001</b>	0.002	1.004	2
48	Accommodation	0.001	0.001	<b>1.002</b>	1.004	3
26	Cosmetics	0.001	0.602	0.001	0.604	4
54	Marketing industrial	0.166	0.340	0.094	0.600	5
53	Marketing of agro-industrial	0.068	0.099	0.091	0.258	6
52	Marketing raw agricultural	0.120	0.061	0.059	0.240	7
55	Marketing services	0.102	0.072	0.063	0.237	8
31	Electricity and water supply	0.017	0.049	0.123	0.189	9
46	Educational	0.064	0.037	0.035	0.136	10
40	Bank and financial	0.030	0.023	0.047	0.100	11
22	Handicraft, gift and souvenirs silk	0.000	0.090	0.000	0.090	12
37	Local transportation service	0.024	0.015	0.013	0.052	13
19	Other food and beverage	0.018	0.018	0.015	0.051	14
13	Butcher beef and pork	0.013	0.019	0.018	0.050	15
63	Local government	0.021	0.016	0.013	0.050	16
39	Communication	0.015	0.014	0.011	0.040	17
27	Retail and wholesale vehicles	0.013	0.019	0.008	0.040	18
25	Retail for commuting expenditures (car fuel)	0.012	0.009	0.017	0.038	19

*Source: Calculations based on data from Mukdahan Social Accounting Matrix*

Special occasion travel and tours has the highest direct effect and overall tourism score. One million baht invested in the tourism sector can create 1.01 million baht of gross income. The largest individual effect of tourism investment is upon the cosmetics sector (604,000 baht). However, in terms of marketing, the joint impacts on industrial, agro-industrial, raw agricultural trade, and marketing services total a substantial 1.335 million for every million baht invested. Similarly, the impacts of tourism on the banking/financial and insurance sectors total 0.116 million. When we consider the impact of each tourism subcomponent, special occasion travel and tours has a full induced effect on marketing and financial services of 1.44, followed by accommodation at 1.11. We therefore cannot reject hypothesis 2.

*H3: The overall value-added, employment, and household income multipliers of EWEC transportation and tourism rank substantially above those of other economics activities in Mukdahan.*

The highest value-added (VA) and gross income (GI) multipliers are associated with tobacco, alcoholic and betel nut, with values of 1.24 and 4.32, respectively (Table 8). Although special occasion travel and tours ranks second in value-added impacts (1.23), accommodation ranks 9<sup>th</sup> (0.98) out of the total 28 activities listed in Table 8; other activities (spa, coiffure) rank 15<sup>th</sup> (0.77); and road construction, local transportation, and vehicle repair

and maintenance 18<sup>th</sup>, 24<sup>th</sup>, and 28<sup>nd</sup>, respectively,. Overall then, the transportation and tourism subsectors rank significantly below several other general economic activities in bringing needed value-added to the Mukdahhan provincial economy.

In terms of employment creation multipliers (EM) as well, tobacco, alcohol and betel nut rank highest, followed by house servants and healthcare and medicine. Accommodation and special occasion travel and tours also rank 7<sup>th</sup> and 9<sup>th</sup>. In stark contrast, however, road construction, local transportation, and vehicle repair and maintenance rank only 19<sup>th</sup>, 23<sup>rd</sup>, and 28<sup>th</sup> in job creation as compared with all 28 SEM matrix activities listed in the table.

Separating the results by geographic zone (columns labeled RI, SI and UI), we find that investments in tobacco, alcohol and betel nut, other donations and educational donation are the most effective for raising income the rural areas. Social transfers, direct donations and other donations have the greatest impact in the semi-urban areas; while tobacco, alcohol and betel nut, special occasion travel and tours, and laundry have the largest impact on urban income. Except for special occasion travel and tours, the entire transportation and tourism blocs figure nowhere in these strategies by location. The results of table 8 therefore lead to clear rejection of hypothesis 3.

**Table 8. Decomposition of some high and low-valued multipliers by bloc in the Mukdahan provincial economy**

Number	Activity	Absolute value of the multiplier						Rank of the multiplier						Average rank
		GI	VA	EM	RI	SI	UI	GI	VA	EM	RI	SI	UI	
<u>Transportation (EWEC)</u>														
36	Road construction service	3.23	0.51	0.17	0.10	0.12	0.06	19	17	18	22	22	22	20
37	Local transportation service	2.85	0.32	0.15	0.06	0.09	0.05	22	23	22	24	24	24	23
38	Vehicle repair and maintenance	1.14	0.03	0.01	0.01	0.01	0.00	27	27	27	27	27	27	27
	<b>Total transportation</b>	<b>7.22</b>	<b>0.86</b>	<b>0.33</b>	<b>0.17</b>	<b>0.22</b>	<b>0.11</b>	<b>23</b>	<b>22</b>	<b>22</b>	<b>24</b>	<b>24</b>	<b>24</b>	<b>23</b>
<u>Tourism</u>														
47	Special occasion travel and tours	4.17	1.23	0.36	0.21	0.54	0.33	5	2	8	9	6	2	5
48	Accommodation	3.29	0.98	0.53	0.19	0.26	0.13	18	9	6	14	17	19	14
45	Other activities (spa, coiffure)	4.03	0.77	0.16	0.14	0.30	0.16	10	14	20	20	16	15	16
	<b>Total tourism</b>	<b>11.49</b>	<b>2.98</b>	<b>1.05</b>	<b>0.54</b>	<b>1.10</b>	<b>0.62</b>	<b>11</b>	<b>8</b>	<b>11</b>	<b>14</b>	<b>13</b>	<b>12</b>	<b>12</b>
<u>General economic activities</u>														
18	Tobacco, alcoholic, betel nut	4.32	1.24	1.11	0.36	0.47	0.35	2	1	1	1	8	1	2
42	Health care and medicine	3.83	1.15	0.89	0.24	0.41	0.24	14	5	3	6	12	8	8
49	Laundry	4.06	1.18	0.16	0.21	0.54	0.31	8	3	19	10	7	3	8
50	House servants	3.78	1.10	0.90	0.23	0.38	0.23	15	6	2	7	14	9	9
43	Recreation and sports	4.13	1.05	0.23	0.19	0.46	0.27	7	8	12	15	10	4	9
44	Massage	3.77	1.09	0.35	0.20	0.42	0.24	16	7	10	12	11	7	11
46	Educational expenditures	3.16	0.93	0.82	0.20	0.31	0.18	20	10	4	11	15	14	12
<u>Insurance and financial</u>														
40	Bank and financial	4.03	1.15	0.13	0.20	0.47	0.26	11	4	24	13	9	5	11
41	Insurance	3.14	0.91	0.28	0.16	0.21	0.09	21	11	11	19	20	20	17
	<b>Total financial and insurance</b>	<b>7.17</b>	<b>2.06</b>	<b>0.41</b>	<b>0.36</b>	<b>0.68</b>	<b>0.35</b>	<b>16</b>	<b>8</b>	<b>18</b>	<b>16</b>	<b>15</b>	<b>13</b>	<b>14</b>
<u>Marketing</u>														
54	Marketing industrial	2.31	0.52	0.17	0.10	0.12	0.06	24	16	17	21	21	21	20
52	Marketing raw agricultural	2.45	0.34	0.22	0.08	0.11	0.06	23	21	13	23	23	23	21
53	Marketing of agro-industrial	2.03	0.28	0.09	0.05	0.07	0.03	26	25	25	25	25	26	25
55	Marketing services	2.17	0.23	0.09	0.04	0.07	0.04	25	26	26	26	26	25	26
	<b>Total marketing</b>	<b>8.96</b>	<b>1.37</b>	<b>0.57</b>	<b>0.27</b>	<b>0.37</b>	<b>0.19</b>	<b>25</b>	<b>22</b>	<b>20</b>	<b>24</b>	<b>24</b>	<b>24</b>	<b>23</b>



<u>Donations</u>														
59	Educational donations	4.15	0.71	0.58	0.29	0.38	0.25	6	15	5	2	13	6	8
	Other and environmental													
60	donations	4.19	0.41	0.21	0.29	0.74	0.19	4	18	14	3	3	11	9
58	Direct donation	4.04	0.36	0.19	0.28	0.79	0.18	9	19	15	4	2	13	10
87	NGOs	3.92	0.35	0.18	0.26	0.72	0.19	12	20	16	5	4	12	12
57	Religious activities expenditure	4.28	0.30	0.15	0.23	0.64	0.15	3	24	23	8	5	16	13
	<b>Total donations</b>	<b>20.58</b>	<b>2.13</b>	<b>1.31</b>	<b>1.35</b>	<b>3.27</b>	<b>0.96</b>	<b>7</b>	<b>19</b>	<b>15</b>	<b>4</b>	<b>5</b>	<b>12</b>	<b>10</b>
<u>Government</u>														
63	Local government	4.48	0.85	0.44	0.16	0.26	0.15	1	13	7	17	18	17	12
61	Social transfers	3.91	0.32	0.16	0.17	0.83	0.22	13	22	21	16	1	10	14
62	Local public admin	3.47	0.89	0.36	0.16	0.26	0.15	17	12	9	18	19	18	16
	<b>Total government</b>	<b>11.86</b>	<b>2.06</b>	<b>0.96</b>	<b>0.49</b>	<b>1.35</b>	<b>0.52</b>	<b>10</b>	<b>16</b>	<b>12</b>	<b>17</b>	<b>13</b>	<b>15</b>	<b>14</b>

**Legend: GI = gross income, VA = value added, EM = employment, RI= rural income, SI = semi-urban income, UI = urban income**

*Source: Calculations based on data from Mukdahan Social Accounting Matrix*

*H4: Religious institutions exert multiplier effects that are more effective in reducing poverty than those of direct donations, NGOs, or government transfers.*

Table 8 further allows us to compare the impacts on poverty reduction of charitable giving (direct donations, educational donations, other donations, NGOs, and religious activity expenditures) vs. those of the government or marketing sectors. Healthcare and medicine (1.15), educational expenditures (0.93), local public administration (0.89) and local government (0.85) all yield greater value added (VA) impacts to the overall economy than those of any form of charitable giving, the highest of which is from educational donations (0.71). The multiplier impacts in creating employment (EM) of healthcare and medical investments (0.89) and of educational expenditures (0.82) clearly outrank those of the form of donation with the highest multiplier (educational donations at 0.58). We must therefore reject H4.

The careful application of this conclusion to policy interventions must, however, pay attention to major differences by geographical zone. The above patterns do roughly apply in the urban areas, where healthcare and medicine (0.24) and social transfers (0.22) are topped only by one form of donation (educational at 0.25). And in the semi-urban zone, direct donations (0.79) and other donations (0.74) are dominated by the powerful poverty-reduction impacts of publicly financed social transfers (0.83). However, a completely different pattern appears in the rural areas. There, donations of all types, notably other donations at 0.29, outpace public and private sector economic activities of all types. We therefore come to a strong secondary conclusion with respect to hypothesis 4: that charitable institutions and households wishing to make charitable contributions can make their giving “count” the most in terms of poverty reduction by channeling donations to rural populations.

*Hypothesis 5: Charitable donations and direct transfers to poor households constitute the most effective sufficiency economy social strategy.*

Even though religious institutions and direct donations lack effectiveness in terms of narrowly-defined poverty reduction in the semi-urban and urban areas, they may still be the most effective agents for the full implementation of all six principles of the King’s Sufficiency Economy (SE) philosophy. We may define the net SE multiplier as the sum of the educational expenditure (*knowledge*), health expenditure (*self-immunization*), *wat* and community expenditure (*ethics*), and earned income to the poor (*ethics* and *self-immunization* against social unrest) multipliers minus the undesirable pollution (*unreasonableness*) and gambling (*unethics*) multipliers (Table 9).

The results show that the top five SE multiplier scores are associated with private and non-governmental charitable behavior: religious activities expenditure (2.77), direct donations (2.18), educational donations (2.15), other donation (2.13), and NGOs (2.13). Among government activities, although publicly financed social transfers rank 6<sup>th</sup>, local government (ranked 16<sup>th</sup>) is currently not a particularly effective vehicle for sufficiency economy implementation. The households to which direct giving and social transfers will have the greatest sufficiency economy impacts are primarily *poor* (quintiles 1 and 2) and *non-urban*, in order: RHH1, SHH2, SHH1, RHH2, UHH2, and UHH1. We therefore strongly fail to reject hypothesis 5.

**Table 9.** Decomposition of the sufficiency economy multipliers for the 19 most promising SEM matrix activities in Mukdahan province

<i>SEM matrix activity</i>	<i>Social impact</i>							Suffic. economy multiplier rank
	<i>a_Education</i>	<i>b_Health</i>	<i>c_Wat/communi ty</i>	<i>d_Earned income to poor</i>	<i>e_Pollution (lower is better)</i>	<i>f_Gambling (lower is better)</i>	Net SE ( <i>a+b+c+d-e-f</i> )	
Religious activities	0.08	0.01	1.88	0.83	0.02	0.01	2.77	1
Direct donation	0.09	0.01	1.09	1.02	0.03	0.01	2.18	2
Educational don.	0.68	0.01	1.05	0.43	0.02	0.00	2.15	3
Other donations	0.10	0.02	1.08	0.96	0.03	0.01	2.13	4
NGOs	0.09	0.02	1.12	0.94	0.03	0.01	2.13	5
Social transfers	0.09	0.01	1.28	0.22	0.02	0.01	1.58	6
RHH1	0.13	0.01	0.09	1.06	0.03	0.01	1.26	7
SHH2	0.10	0.02	0.09	1.05	0.03	0.01	1.23	8
SHH1	0.09	0.01	0.09	1.05	0.03	0.01	1.22	9
RHH2	0.11	0.01	0.08	1.04	0.03	0.01	1.21	10
UHH2	0.07	0.01	0.09	1.06	0.04	0.01	1.18	11
Health care + med.	0.05	1.06	0.03	0.05	0.02	0.00	1.18	12
UHH1	0.04	0.02	0.07	1.05	0.05	0.01	1.12	13
Education exp.	1.04	0.01	0.03	0.04	0.01	0.00	1.11	14
Agricultural labor	0.07	0.01	0.05	0.41	0.02	0.01	0.52	15
Local government	0.14	0.12	0.02	0.04	0.02	0.00	0.31	16
RHH3	0.18	0.04	0.03	0.03	0.02	0.00	0.26	17
Buildings and land	0.08	0.02	0.06	0.11	0.02	0.01	0.23	18
SHH4	0.15	0.01	0.06	0.04	0.02	0.01	0.23	19

*Source: Calculations based on data from Mukdahan Social Accounting Matrix*

*H6: Road construction, wats, and employment creation in border tourism should optimally receive increased aggregate investment; while government programs should be substantially reduced.*

The optimal net provincial products of Mukdahan under the **SAM**, **ESAM** and **SEM** are 31,686, 20,737 and 18,267 million baht, respectively; as compared to the current level of 22,170 million baht (Table 10). The **SAM** result points to severe inefficiency in current economic structure, since we may increase net provincial social product by 43% by simply re-allocating existing resources.

Moreover, the net costs of introducing a reduced-pollution (**ESAM**) or even implementing a full sufficiency-economy (**SEM**) plan over the current situation are only about 1.4 and 3.9 m baht, respectively, since once again, activities are optimally re-distributed for maximum efficiency. But since aggregate value added decreases substantially with the progressive addition of environmental and sufficiency economy constraints, provincial planners face a clear a trade-off between economic growth and all-round socioeconomic development in their choice among alternative development strategies.

**Table 10.** Comparative total values of the current situation and the optimal plans under the SAM, ESAM, and SEM formulations

Situation or plan	Net provincial product	Road construction	Religious institution (wats)	Tourism Service labor	Gov't	NGOs
CURRENT	22,170.0	218.1	432.0	3302.5	1649.0	177.3
SAM	31,686.0	300.6	554.1	4292.5	2613.9	228.5
<i>% change under SAM</i>	43%	38%	28%	30%	59%	29%
ESAM	20,737.0	153.8	368.8	2612.6	1159.0	135.2
<i>% change under ESAM</i>	-7%	-29%	-15%	-21%	-30%	-24%
SEM	18,267.0	165.7	1048.2	3498.2	1231.4	138.6
<i>% change under SEM</i>	-18%	-24%	143%	6%	-25%	-22%

Source: Calculations by the authors using the Solver linear optimization routine in EXCEL.

The **SAM** optimum calls for increased exogenous investment in road construction (38%), *wats* (28%), tourism service employment (30%), government programs (59%), and NGOs (29%). Although in the **SEM** optima, most types of activities are reduced, the optimal plan still calls for an increased role for both religious institutions (+143%) and employment creation in service sector (+6%). These results confirm that provincial government should be promoting investment in road construction and the production and advertising of tourism to support expanded tourism market employment. Government should also support religious institutions as effective channels for income redistribution. We therefore fail to reject hypothesis 6.

*H7: The optimized SAM, ESAM and SEM lead to significantly different plans for economic development and poverty reduction in Mukdahan province, giving further support to the importance of studying and applying the Kings Sufficiency Economy.*

The major upward and downward swings of a few key activities (Table 11) are quite striking as one moves from the current situation to the optimal **SAM**, **ESAM**, and **SEM** plans. For example, the banking and financial sector first rises by 608% as one moves from the current situation to the SAM, and then falls to 18% and 23% below the current situation in the ESAM and SEM! Education first rises by 31%, then falls by -15%, then rises by 25%.

**Table 11.** Changes in the optimal levels of key activities by plan

No.	Activity	CURRENT	SAM	% change from Current	ESAM	% change from Current	SEM	% change from Current
			8,809					
40	Bank/financial	1,243.5	.7	608%	1,020.5	-18%	952.9	-23%
50	House servants	5.5	7.7	39%	4.1	-26%	4.0	-27%
36	Road construction service	218.1	300.6	38%	153.8	-29%	165.7	-24%
42	Health care and medicine	450.6	619.0	37%	359.3	-20%	354.3	-21%
43	Recreation and sports	26.0	35.4	36%	20.7	-20%	19.9	-23%
47	Special occasion travel and tours	242.8	329.5	36%	195.0	-20%	186.3	-23%
35	Construction service	391.4	523.9	34%	309.9	-21%	298.9	-24%
			2,662				2,541.	
46	Education	2,033.4	.6	31%	1,722.3	-15%	8	25%
56	Lottery tickets and gambling	142.4	186.3	31%	123.4	-13%	113.9	-20%

No.	Activity	CURR ENT	SAM	% change from Current	ESAM	% change from Current	SEM	% change from Current
	Local transportation		1,450					
37	service	1,158.5	.9	25%	945.9	-18%	906.0	-22%
18	Tobacco, alcoholic	232.4	261.9	13%	4,824.8	1976%	166.4	-28%
	Marketing of raw		5,765				3,680.	
52	agricultural	4,646.0	.7	24%	3,883.5	-16%	9	-21%
10	Rice mill	462.6	573.6	24%	386.2	-17%	366.2	-21%
	Marketing of agro-		4,421				2,836.	
53	industrial	3,620.2	.5	22%	2,933.2	-19%	0	-22%
15	Dairy products	2.0	2.4	22%	1.6	-19%	1.6	-22%

Source: Calculations by the authors using the Solver linear optimization routine in EXCEL.

Of course, the fundamental reason underlying these shifting weights is the increasing marginal cost of certain limiting constraints to the optimal solution (Table 12). The **SAM** formulation reveals that only the labour constraint is currently binding on the Mukdahan economy. Its shadow price (0.108 m baht) reflects the marginal value to the economy of adding one additional labourer on an annual basis to ease that constraint.

Moving on to the **ESAM**, the pollution constraint becomes binding because we force maximum pollution to fall to 75% of that in the current situation. The cost of this constraint is some 1,433 million baht, or 6.5% of current net provincial social product (NPSP). Social planners must now choose is that "worth it" in terms of improving the environment.

**Table 12.** Constraint table of the SAM, ESAM and SEM linear programming models

Constraint name	CURRENT	SAM		ESAM		SEM				
	2009	Final Value	Shadow Price	Final Value	Shadow Price	Final Value	Shadow Price	Constraint level	Allowable increase	Allowable decrease
Land	128,094	146,375	0.000	95,049	0.000	94,355	0.000	153,713	Infinite	59,358
Labor	243,442	292,131	0.108	195,024	0.000	203,885	0.000	365,163	Infinite	161,278
Capital	47,823	53,896	0.000	34,150	0.000	33,434	0.000	57,388	Infinite	23,953
Pollution score	4,447	5,193	<i>n.a.</i>	3,336	6.22	3,287	0.000	3,336	Infinite	49
Gambling expenditure score ( <i>balance, ethics, etc.</i> )	142	186	<i>n.a.</i>	123	<i>n.a.</i>	114	0.000	114	2	27
Health Expenditure score ( <i>self-immunization</i> )	452	615	<i>n.a.</i>	357	<i>n.a.</i>	565	-0.167	565	832	213
Wat and Community Expenditure ( <i>ethics</i> )	1,279	1,640	<i>n.a.</i>	1,099	<i>n.a.</i>	1,598	0.000	1,598	1,609	455
Educational Expenditure score ( <i>knowledge</i> )	2,033	2,663	<i>n.a.</i>	1,722	<i>n.a.</i>	2,542	-1.097	2,542	1,265	494
SE score ( <i>balance</i> )	-509	-99	<i>n.a.</i>	-47	<i>n.a.</i>	1,424	0.000	0	1,424	Infinite
<b>Income distributional impact (ethics, self-immunization)</b>										
Quintile ratio	4.06	4.99		5.08				3.29		

Source: Calculations by the authors using the Solver linear optimization routine in EXCEL.

Finally, under the **SEM**, we assume that labour, in addition to being less disguisedly unemployed, will also become significantly more motivated to work more effectively as the sufficiency economy spirit permeates the economy. Hence the limit on effective labour availability is expanded by 50%. We also wish to increase the SE-related health, education, and wat-community expenditures by at least 25% each and reduce gambling by a similar proportion.

Under these conditions, both health and education become the binding constraints. Increasing health expenditures from 452 currently to 567 in the spirit of self-immunization makes the marginal benefit (negative shadow price) of relaxing the health constraint by 1 million baht (i.e. from 567 to 566) a full 0.167 m baht. The corresponding value for education is much higher: the economy would gain 1.067 m baht in nominal income increase for every 1 million baht reduction in the required minimum level of education spending.

It is only this last (**SEM**) plan that has a significant impact on poverty reduction (the quintile ratio of 3.29 is by far the lowest of all plans), as a result of the significantly shifting balance among planning activities. In fact the **SAM** and **ESAM** formulations actually increase the level of inequality (quintile ratios of 4.99 and 5.08) We thus fail to reject hypothesis 7.

*H8: The SAM, ESAM and SEM optimizations, being realistically constrained by resources and planning objectives, give substantially different and logically superior guidelines for private entrepreneurship and public policy than unconstrained multiplier analysis.*

To test this hypothesis we must compare the narrowly economic **SAM** optimal allocations with those given by narrowly economic value added multipliers; and the broadly social SEM optimal allocations with the broadly social average multiplier ranks (Table 13).

**Table 13.** Comparisons of activity ranks under traditional multipliers vs. linear optimization

No.	Activity	Narrow economic analysis		Broad social analysis	
		(a) VA multiplier rank	(b) % change from Current to SAM optimum	(c) Average rank across all multipliers	(d) % change from Current to SEM optimum
18	Tobacco, alcoholic, betel nut	1	13%	2	-28%
47	Special occasion travel/tours	2	36%	5	-23%
40	Bank and financial	4	608%	11	-23%
42	Health care and medicine	5	37%	8	-21%
50	House servants	6	39%	9	-27%
43	Recreation and sports	8	36%	9	-23%
36	Road construction service	17	38%	20	-24%
52	Marketing raw agricultural	21	24%	21	-21%
37	Local transportation service	23	25%	23	-22%
53	Marketing of agro-industrial	25	22%	25	-22%

Source: Calculations by the authors using the Solver linear optimization routine in EXCEL.

Activities in the table are first sorted by rank of the VA multiplier (column a). If there were convergence between the two types of analysis in terms of narrowly economic recipes for growth, we would therefore expect the values in column b to descend systematically in the same order. Instead, however, 4<sup>th</sup> ranked bank and financial activity enjoys a 608% increase under the SAM optimum; and 17<sup>th</sup>-ranked road construction service increases more (38%) than 2<sup>nd</sup> ranked special occasion travel and tours.

Similarly, as the average total rank across all multipliers (column c) declined, we would expect the values in column d to suffer greater and greater reductions. Instead, the greatest loss of importance under the optimized SEM is for 1<sup>st</sup> ranked tobacco, alcoholic and betelnut (28%), followed by 9<sup>th</sup>-place house servants (27%)!

There is clearly little convergence or even similarity between the results of the two types of analyses. Yet billions of baht of annual budgeting depend upon the relative investment priorities chosen by government. We strongly feel, for the reasons cited throughout this paper, that SAMs and SEM optimizations, being realistically constrained by resources and planning objectives, give significantly different and logically superior guidelines to private entrepreneurship and public policy than traditional unconstrained multiplier analysis. We therefore fail to reject hypothesis 8.

## 7. Summary, conclusions and strategic/policy implications

### Summary and conclusions

This paper has used Sufficiency Economy Matrix multiplier and optimization analyses to estimate the impacts of the East West Economic Corridor on economic growth, poverty reduction and the implementation of the sufficiency economy philosophy in Mukdahan province, Thailand. We have rejected two research hypotheses:



*H3: The overall value-added, employment, and household income multipliers of EWEC transportation and tourism rank substantially above other economic activities in Mukdahan.*

*H4: Religious institutions exert multiplier effects that are more effective in reducing poverty than those of direction donations, NGOs, or government transfers.*

However, we have failed to reject (or, loosely speaking, “accepted”) our remaining six research hypotheses:

*H1: The EWEC exerts high and widespread multiplier effects on marketing, communication, and financial services in Mukdahan.*

*H2: Tourism exerts high and widespread multiplier effects on marketing and financial services in Mukdahan.*

*H5: Charitable donations and direct transfers to poor households constitute the most effective sufficiency economy social strategy.*

*H6: Road construction, wats, and employment creation in border tourism should optimally receive increased aggregate investment; while government programs should be substantially reduced.*

*H7: The optimized SAM, ESAM and SEM lead to significantly different plans for economic development and poverty reduction in Mukdahan province, giving further support to the importance of studying and applying the King’s Sufficiency Economy.*

*H8: The SAM, ESAM and SEM optimizations, being realistically constrained by resources and planning objectives, give substantially different and logically superior guidelines for private entrepreneurship and public policy than standard, unconstrained multiplier analysis.*

The non-rejection of this last hypothesis casts some doubt on the true rejection/non-rejection of the preceding hypotheses 1 through 5 since they were tested with partial-equilibrium multiplier analysis. However, we shall assume that they are correct; since re-testing them with other methods would be beyond the scope of this paper. The clear recommendation that emerges is that government can obtain a first-round feeling for the economic and social impacts of various activities and sectors within the economy on economic growth, pollution and gambling reduction, and socio-economic development; but that planners must also attempt to build and optimize a model of the economy under alternative sets of constraints or philosophical principles in order to develop an integrated and correct plan consistent with the Kings of Thailand’s accept on “balance.”

We recommend that further studies of this type be applied at the provincial and national levels in Thailand and other developing nations in order to critically evaluate and realistically fine-tune the objectives of 5-year plans. The social efficiency gains of such research could be enormous.

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