Sustainable Growth and Employment, Poverty, Energy, Pollution and Transportation in Yunnan, China: a Social Accounting Matrix Approach[1]

Ma Ji[2]
Peter H. Calkins[3]

Abstract

The Chinese government at both national and provincial levels has realized that a balanced and sustainable development strategy must replace the uni-dimensional emphasis on GDP growth in order to lead the nation to a brighter future and resolve the current conflict between economic growth and social development.

The present research was carried out by applying macroeconomic and meso-economic methods of social accounting to data from Yunnan province. The bulk of this research is devoted to firstly developing a Social Accounting Matrix (SAM) for Yunnan by organizing information about the economic and social structure of the economy of the province in 2002; secondly, to using the SAM to calculate various development multipliers; and thirdly to transforming the matrix into a linear program to calculate optimal resource use and sectoral production levels under various resource constraint scenarios.

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1 This article is a partial fulfillment of Thesis in Master of Economics, Faculty of Economics, Chiang Mai University
2 The author is Graduate student, respectively, Faculty of Economics, Chiang Mai University.
3 Professor of Faculty of Economics, Chiang Mai University.

The recommendations that flow from this article are that the government should increase investment in agriculture but that subsectoral adjustments should encourage bean production, animal husbandry and forestry rather than grain crop farming to increase productive efficiency. Furthermore, external investments should be combined with a more propitious policy environment to improve telecommunications and logistics and to expand and improve financial and insurance services.

Keywords: Sustainable Growth, Social Accounting Matrix, Yunnan, Environment, Poverty

01. Introduction

China has sustained high economic growth rate for the past three decades, thus greatly developing its economic and social situation. But economic growth has been accompanied by many social and environmental problems, such as high environmental pollution, an increasing gap between rich and poor, and over-consumption of energy. Indeed, China is notorious in development circles for the tremendous increase in industrial and urban pollution that has both given China the vast majority (17 out of 22) of the most polluted cities in the world and threatened to postpone the Beijing Olympics in 2008. China is also known for the widening gap in incomes between the rich and the poor, and especially between the prospering eastern coast and the stagnating rural hinterland. As in any country, the level and volatility of energy prices have led to the search for alternative biological and solar sources of energy.

The Chinese government at both national and provincial levels has realized that a balanced and sustainable development strategy must replace the uni-dimensional emphasis on GDP growth in order to lead the nation to a brighter future and resolve the current conflict between economic growth and social development. It also knows that despite its discontents, globalization based on trade expansion is the most promising engine to propel that development. Any development plan that will create enough social capital to solve the non-growth objectives of development must therefore make full use of the profound investment in infrastructure that has resulted from the Asian Development Bank's initiative to link Kunming, the capital of Yunnan province, with Eastern China and the remaining Greater Mekong Sub region (GMS).

This article intends to explore "walking on two legs"[4] : a combination of sustainable development objectives in terms of not only traditional GDP growth but also such environmental and social objectives as employment creation, poverty alleviation, energy independence, environmental protection, and full use of the transportation network. These six aspects are commonly considered as the core part of a sustainable development economy which fulfills the principle of sustainability of a maximum growth target without deteriorating the welfare of the next generation. Toward this end, this article will combine the results from multiplier analyses and linear programming optimizations to identify the possible complementarities and trade-offs between narrow improvements in income and broader socioeconomic and environmental objectives.

The overall aim of the article is to give separate and interrelated accounts of the sustainable development goals of the Yunnan Economy in terms of growth of GPP, energy dependency, transport dependency, environmental degradation, poverty alleviation, and employment creation. This will be achieved by applying both macroeconomic and meso-economic methods of Social Accounting Matrix (SAM) to data from Yunnan province. Once constructed at both levels, the SAMs will be employed to conduct a systematic analysis of the economy of Yunnan in 2002 through both macroeconomic and mesoeconomic perspectives. In addition, the total provincial value added of the mesoeconomic SAM will be optimized using linear programming techniques, subject to the other socioeconomic and environmental objectives that constitute the second "leg" of Chinese development.

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[4] This phrase was used during the Mao Zedong period, 1949-1976, to refer to sub periods where both economic incentives and socioeconomic ideology were set as twin targets.

Based on the multiplier and linear programming analyses of the 2002 Social Accounting Matrix for Yunnan, the article will answer the following research questions:

- Which sectors of the Yunnan economy should be targeted for exogenous investments (by government, banks, the rest of China, and the foreign sector) in order to maximize GPP as measured by value added (VA)?
- Which sectors of the Yunnan economy should be targeted for exogenous investments in order to minimize environmental degradation?
- Which sectors of the Yunnan economy should be targeted for exogenous investments in order to minimize energy dependency?
- Which sectors of the Yunnan economy should be targeted for exogenous investments in order to make the fullest use of the net transportation infrastructure?
- Which sectors of the Yunnan economy have the greatest potential for increasing employment?
- Which sectors of the Yunnan economy have the greatest potential for alleviating poverty?
- Which among land, labor, and capital is the most binding factor constraint to future increases in the VA?
- Do the same sectors of the economy occupy the top rank across all types of multiplier (value added, employment creation, environmental degradation, energy dependency, poverty alleviation, full use of transportation)?
- Do linear programming and the integrated multiplier analysis lead to the same ranking of priority sectors for balanced growth?
- Which government policies would be most favorable to the reorientation of the economic globalization in the way dictated by the balanced linear programming scenario?

02. Social Accounting Matrix for Yunnan, 2002

2.1 The Macro SAM

Since 1987, China has started to build input-output (I-O) tables every 5 years. In 1993, China undertook GDP accounting according to the basic principles and methods of systems of national accounts (SNA); and now China has established the system of annual and quarterly GDP accounting both for the nation and by region. In the last years of the 1980s, the National Bureau of Statistics (NBS) began to research accounting methods of SNA. Therefore, the system of periodic compilation of I-O tables is established in China, whereby a large-scale input-output survey will be carried out and the basic input-output table compiled when the year ends in a 2 or a 7; and summary input-output tables will be compiled through small-scale surveys and the adjustment of basic indicator tables when the year ends in a 0 or a 5. In the earlier 1990s, NBS established the basic table and compilation methods of national accounts in China. At this writing, national accounts of 1997-2003 have been compiled and made available for research. The above considerations give the essential conditions for building a Social Accounting Matrix of both national and regional in China.

The 2002 descriptive Macro SAM for Yunnan (table1) is a square matrix comprising 11 rows and columns forming separate accounts in the economy, plus a twelfth column and row to show totals. The framework of a Macro SAM is constructed by 31 non-empty[5] cells which present all transactions of the economy for Yunnan province in 2002. The columns represent the expenditures (or inputs) of the account in question to other accounts and the rows represent the incomes (or outputs) coming into that account from other accounts. Table 2 reports the algebraic symbols for the non-empty cells to be used in the remainder of this article.

5 *The empty cells show transactions that are inconsistent with the definitions and principles of macroeconomics.*

Table 1. A 2002 Macro SAM for Yunnan

	CA	VA-L	VA-K	Household	Enterprise	Gov-L	Gov-E	Gov-C	CAP	ROMC	ROW	ROWSUM
CA	2,737	–	–	1,025	–	451	50	212	887	763	118	6,244
VA-L	1,020	–	–	–	–	–	–	–	–	–	–	1,020
VA-K	725	–	–	–	–	–	–	–	–	–	–	725
Household	–	1,020	161	–	–	76	–	2	–	–	–	1,259
Enterprise	–	–	565	–	–	–	–	–	–	–	–	565
Gov-L	172	–	–	9	26	–	–	335	–	–	–	542
Gov-E	50	–	–	–	–	–	–	–	–	–	–	50
Gov-C	495	–	–	–	31	14	–	–	–	9	–	549
CAP	–	–	–	225	508	1	–		–	207	-52	887
ROMC	978	–	–	–	–	–	–	–	–	–	–	978
ROW	66	–	–	–	–	–	–	–	–	–	–	66
COLSUM	6,244	1,020	725	1,259	565	542	50	549	887	978	66	

Source: calculated by the authors.

Table 2. The dimensions of the Meso SAM

	CA	VA-L	VA-K	Household	Enterprise	Gov-L	Gov-E	Gov-C	CAP	ROMC	ROW	ROWSUM
CA	C_I (41X41)	-	-	C_F (41X12)	-	G_L (41X1)	G_E (41X1)	G_C (41X1)	I (41X1)	X_D (41X1)	X_W (41X1)	AD
VA-L	W_V (3X41)	-	-	-	-	-	-	-	-	-	-	Y_{FL}
VA-K	R_K (1X41)	-	-	-	-	-	-	-	-	-	-	Y_{FK}
House hold	-	W_H (12X3)	RK_H (12X1)	-		G_{TLH} (12X1)		G_{TCH} (12X1)	-	-	-	Y_H
Enter prise	-	-	RK_E (1X1)	-	-	-		-	-	-	-	Y_E
Gov-L	T_{IDL} (1X41)	-	-	T_{HI} (1X12)	T_{EIL} (1X1)			GTCL (1X1)	-	-	-	Y_{GL}
Gov-E	T_{EB} (1X41)											Y_{GE}
Gov-C	T_M + T_{IDC} (1X41)	-	-	-	T_{EIC} (1X1)	G_{TLC} (1X1)			-	G_{CROMC} (1X1)	-	Y_{GC}
CAP	-	-	-	S_H (1X12)	S_E (1X1)	S_G (1X1)			-	S_D (1X1)	S_W (1X1)	S
ROMC	M_D (1X41)	-	-	-	-	-		-	-	-	-	Y_{ROMC}
ROW	M_W (1X41)	-	-	-	-	-		-	-	-	-	Y_{ROW}
COLSUM	AS	E_{FL}	E_{FK}	E_H	E_E	E_{GL}	E_{GE}	E_{GC}	I	E_{ROMC}	E_{ROW}	

Source: designed by the authors.

2.2 The Meso SAM

For effective sectoral planning, some cells in the Macro SAM must be disaggregated into specific sub-matrices to reflect and explore policy emphases. The result is called a disaggregated or Meso SAM. Those cells found from a specific data source may be used directly. However, those that cannot may be estimated technically based on a series of careful assumptions. In this way, the dimensions of the Macro SAM shown in table 2 sum up the 64 by 64 activities which sum identically to the row and column totals given in table 1.

03. Research method

3.1 Accounting Multiplier Matrix

Based on these assumptions, the Meso SAM will be used to build the multiplier matrix to evaluate the effect of a single change or injection of exogenous capital into one or a set of endogenous accounts. To build the SAM-based multiplier model, one must compute column shares (the "A" matrix of column coefficients) from the initial money SAM to generate matrix multipliers ($1-A^{-1}$). The matrix of endogenous transactions will be denoted by the matrix T, and the column shares matrix will be denoted by the matrix A, which is divided into elements in each column of T by its column total.

$$T = Ay \tag{1}$$

The component sub matrices of A are as follows: A_{21} is the matrix of value added share of factor incomes generated by activities; A_{32} is the shares of factor incomes distributed across household, and A_{13} exhibits the pattern of expenditure by each household group. Similarly x and y are the vectors of exogenous injections and account totals, where, for example, x_1 is the vector of all purchases of final goods and services other than those by households and y_1 , is the total demand for products. Then the table 3 can be written as

$$\begin{aligned} Y &= Ay + X \\ &= (I - A)^{-1} X = M_A X \end{aligned} \tag{2}$$

Table 3. The SAM model summarized by endogenous and exogenous accounts

Expense \ Receipts	1.Productive /Activities (Endogenous accounts)	2.Factors (Endogenous accounts)	3.Household (Endogenous accounts)	4.Exogenous accounts	Total
1.Productive activities	T_{11}		T_{13}	X_1	Y_1
2.Factors	T_{21}			X_2	Y_2
3.Household		T_{32}	T_{33}	X_3	Y_3
4.Exogenous accounts	L_1	L_2	L_3	LX	Y_4
Total	Y_1	Y_2	Y_3	Y_4	

Source: Jeffery Round. 2003. Social accounting matrices and in SAM-based models: in retrospect and in prospect, University of Warwick, U.K.

Here, M_A is the SAM multiplier matrix, otherwise known as the matrix of "accounting multipliers." The accounting multipliers compute the simple multiplier effects upon outputs of activities of production and, equally importantly, upon incomes of household groups. Thus multiplier analysis can be used to predict the income distributional impacts of a given investment. The general aggregate multiplier model can be expressed as follows:

$$dy = (I - A)^{-1}\, dx = M_A dx \tag{3}$$

When we deal with complex dynamic economic systems under the objective of balanced growth, we must offset the narrow pursuit of GDP growth with other goals, having to do with employment creation, reduced pollution, reduced energy use, enhanced use of the growing transportation infrastructure, etc. These separate subsets of multipliers each constitute an objective-specific multiplier for a class of rows in the model, and take the following form:

$$\sum_i^n dy_i = \sum_1^n (I - A)^{-1}\, dx = \sum M_{At}\, dx \tag{4}$$

Where

i = a type of labor, pollution industry , energy sector , etc.

Policy makers can then determine the weight shares they assign to value added, pollution, energy, full use of the transportation infrastructure, poverty alleviation, and employment to calculate an aggregate social welfare multiplier for each sector in the economy. In the following sections we shall illustrate this entire process using data from Yunnan province.

3.2 Linear programming Optimization

The A matrix of the Meso SAM shows us a matrix contains elements denoted as. It represents the share of the expenditure of sector j on sector i taking account of total expenditure of sector j. From the previous section we know that:

$$Y = Ay + X \tag{5}$$

$$(I - A)\, Y = X \tag{6}$$

Where

Y is a matrix of total income, and X is a matrix of exogenous capital injections.

Table 4 describes the whole process of linear programming optimization. It should be noted that we employ the matrix, called here $\overline{A_{ij}}$, instead of the or multiplier matrix. Since we assume that total income should be greater than or equal to total expenditure, our calculation is based on the $(I - A)$ matrix, We assume an element in $\overline{A_{ij}}$ to be $\overline{a_{ij}}$. For optimization of the total GPP, this section will define $\overline{V_j}$, a vector with j columns obtained from the value matrix , to denote the percentage of value added in total revenue; $\overline{Y_j}$, a vector with j columns obtained from the value matrix, to denote the 2002 level income of each economic activity; and $\overline{Y_j}$, a vector with j columns, to denote the optimal level of each economic activity. In this way, we can obtain the percentage changes of the optimal over the baseline scenario, denoted as $(\overline{Y_j} - Y_j)$ / Y_j for each sector j.

Table 4. The linear programming optimization matrix

j \ i		Endogenous $j = 1$ to 57	Right-hand side or row limit
% Value added in total revenue	$j = 1$ to 57	V_j	-
Optimal level of each economic activity	$j = 1$ to 57	$\overline{Y}_j$	$\sum_{j=1}^{57} \overline{Y}_{ij} V_j^T$
2002 level of each economic activity	$j = 1$ to 57	Y_j	$\sum_{j=1}^{57} Y_{ij} V_j^T$
% change optimal over 2002	$j = 1$ to 57	$(\overline{Y}_j - Y_j) / Y_j$	
Income expenditure (I-A) balance constraints	$i = 1$ to 57 $j = 1$ to 57	$A_{ij} = \begin{bmatrix} d_{11} & \cdots & d_{1j} \\ \cdots & \cdots & \cdots \\ d_{i1} & \cdots & d_{ij} \end{bmatrix} \times \overline{Y}_j = \sum_{j=1}^{57} A_{ij} V_j^T$	$>= 0$ for each i
Resource constraint	$k = 1$ to 4	$A_{kj} = \begin{bmatrix} d_{11} & \cdots & d_{1j} \\ \cdots & \cdots & \cdots \\ d_{k1} & \cdots & d_{kj} \end{bmatrix} \times \overline{Y}_j = \sum_{j=1}^{57} A_{kj} V_j^T$	$<= B_k$ where k = each production factor

The target of the linear programming optimization is to maximize the optimal level of output $\sum_{j=1}^{57} \overline{Y}_j V_j^T$ in terms of the total value added. With no constraints, the potential value added of an economy is mathematically infinite or "unbounded." Therefore, for both computational tractability and planning realism, the optimal level of output will be readjusted with some constraints. **(1)** The income – expenditure (I-A) balance constraints are the first type of constraint, denoted as $\sum_{j=1}^{57} \overline{A}_{ij} V_j^T$, a vector with j rows that should be greater than or equal to zero for each i on the right hand side in the table. **(2)** Factor resource constraints are the second type of constraint, denoted as $\sum_{j=1}^{57} \overline{A}_{kj} V_j^T$ $(k = 1$ to $4)$, a vector with k rows; these should be less than or equal to B_k where k = each production factor.

According to the principles assumed above, a linear programming optimization was calculated by the Solver macro add-in available in Microsoft Excel. The target cell is the summation of the vector of optimal output level times the vector of the ratio of value added $\sum_{j=1}^{57} \overline{Y}_j V_j^T$. The resource constraints set the limitation with the production factors in terms of the farm land, non farm land, labor and the equity capital.

04. Empirical results

4.1 Integrated Sustainable Development Multiplier Analysis

Since the one economic objective and the five social objectives implicit in walking on two legs are not always mutually consistent and may even conflict with each other, it is necessary to build an integrated sustainable development multiplier to balance the target for achieving maximum economic output and the targets for satisfying the social objectives. In this research, we assume a sustainable development objective intended to encourage the positive effects in terms of the value added multiplier, employment creation multiplier, transportation dependency multiplier, poverty alleviation multiplier, and to decrease the negative effects in terms of the environmental degradation multiplier and the energy dependency multiplier.

To seek a reasonable balance among these objectives, we weighted value-added growth as 50% of our objective and the five environmental and social sustainability objectives as summing equally to the remaining 50%. We then built the integrated sustainable development multipliers in two ways in terms of what we have termed the "inverse" method and the "negative" method, as introduced below:

4.1.1 The inverse method

The $M_{inverse-i}$ was generated by weighting M_{VA-i} , M_{EC-i} , M_{T-i} , M_{P-i} , **with 0.5, 0.1, 0.1, 0.1** and weighting the inversed M_{EV-i} , and M_{EE-i} , **with 0.15 and 0.05** to limit the industries that has negative effects on the environmental and social. The reason for choosing the value of the two multipliers with 0.15 and 0.05, respectively, is that there is some repetition between them, and they are also assumed to be more important in environmental conservation.

$$M_{inverse-i} = 0.5 \times M_{VA-i} + 0.1 \times M_{EC-i} + 0.15 \div M_{EV-i} + 0.05 \div M_{EE-i} + 0.1 \times M_{T-i} + 0.1 \times M_{P-i} \tag{7}$$

The inverse method then brings about the ranking by an inversed integrated sustainable development multiplier $M_{inverse-i}$ in table 5.

Table 5 shows that for achieving the sustainable development integrated objective, the top 10 industries are "textiles and apparel", "electronics, instruments, and office equipment," "waste," "other manufacturing," "equipment," "food and tobacco processing," "finance and insurance," "fishery," "animal husbandry", "forestry" with the biggest inversed integrated sustainable development multipliers.

4.1.2 The negative method

The $M_{inverse-i}$ was constructed by weighting M_{VA-i} , M_{EC-i} , M_{T-i} , M_{P-i} , **with 0.5, 0.1, 0.1, 0.1** and weighting the M_{EV-i} , and M_{EE-i} , **with -0.15 and -0.05** to limit the industries that have negative effects on the environmental and social welfare. The reason for choosing the two multipliers as -0.15 and -0.05 is that there is some repetition between them, and they are also assumed to be more important in terms of environmental conservation.

$$M_{inverse-i} = 0.5 \times M_{VA-i} + 0.1 \times M_{EC-i} - 0.15 \times M_{EV-i} - 0.05 \times M_{EE-i} + 0.1 \times M_{T-i} + 0.1 \times M_{P-i} \tag{8}$$

The inverse method then gives the ranking by an inversed integrated sustainable development multiplier $M_{inverse-i}$ (table 6):

To pursue the sustainable development integrated objective, table 6 shows that the top 10 industries are "beans", "tobacco," "sugar crops," "forestry", "other farming," "animal husbandry", "oil bearing crops," "grain crops," "fishery," "telecommunications and logistics."

Since there is no clear rational for preferring the inverse over the negative approach, we may combining the ranking of the two approaches to obtain the top 17 industries which are chosen by the integrated sustainable development multiplier that show in table 7. We find that three industries have been chosen by both approaches, "fishery," "animal husbandry," and "forestry." These three industries should be encouraged, because they respect the environmental objective by either the inverse method or the negative method.

The top 17 industries indentified by multiplier analysis that should be encouraged by Yunnan government are "textiles and apparel," "beans," "electronics, instruments, and office equipment," "tobacco," "waste," "sugar crops," "other manufacturing," "forestry", "equipment," "other farming," "food and tobacco processing," "animal husbandry", "finance and insurance," "oil bearing crops," "fishery," "grain crops," and "telecommunications and logistics."

Table 6. The integrated multiplier ranking by the negative method

Rank	Sector	The negative integrated multiplier	Rank	Sector	The inversed integrated multiplier
1	Beans	0.983	22	Construction	0.459
2	Tobacco	0.977	23	Accommodation and restaurant	0.458
3	Sugar Crops	0.976	24	Other services	0.455
4	Forestry	0.973	25	Food and tobacco processing	0.421
5	Other Farming	0.968	26	Electricity and heat	0.402
6	Animal husbandry	0.956	27	Fertilizer	0.378
7	Oil bearing Crops	0.943	28	Metal and non-metal manufacturing	0.360
8	Grain Crops	0.916	29	Textiles and apparel	0.331
9	Fishery	0.893	30	Machinery	0.292
10	Telecommunication and logistics	0.796	31	Equipment	0.290
11	Finance and insurance	0.592	32	Other manufacturing	0.282
12	Transportation and storage	0.591	33	Electronics, instruments, and office equipment	0.218
13	Extension services	0.539	34	Other chemicals	0.216
14	Water	0.536	35	Gas	0.186
15	Public administration	0.507	36	Petroleum and natural gas extraction	0.154
16	Scientific research	0.506	37	Pesticides	0.151
17	Retail and wholesale	0.502	38	Coal mining and processing	0.126
18	Metal and non-metal mining	0.487	39	Papermaking	0.111
19	Tourism	0.485	40	Coking	0.080
20	Waste	0.478	41	Oil refining	-0.005
21	Timber and furniture	0.470			

Source: calculated by the A matrix

Table 7. The top 17 sectors for multi-objectives of the sustainable development

Ranking	Inverse ratio	Ranking	Negative
1	Textiles and apparel	1	Beans
2	Electronics, instruments, and office equipment	2	Tobacco
3	Waste	3	Sugar Crops
4	Other manufacturing	4	Forestry
5	Equipment	5	Other Farming
6	Food and tobacco processing	6	Animal husbandry
7	Finance and insurance	7	Oil bearing Crops
8	Fishery	8	Grain Crops
9	Animal husbandry	9	Fishery
10	Forestry	10	Telecommunications and logistics

Source: calculated by the A matrix

4.2 Linear Program Optimization Scenario Analysis

To guide the linear programming optimization of policy targeting, we set out five different strategy scenarios as follows:

1) Base-line situation. The Base-line simulates the output level of 2002, the overall Value-Added for the Yunnan economy, the current economic income for each sector, and the amount of the resource use in terms of each factor input.

2) Land-based strategy. This strategy scenario assumes that the farm land can be improved by 50% by increasing the efficiency of land use and non farm land productivity can be heightened by 30% by increasing the efficiency of land use, the other constraints remain the same or less than original level.

3) Labor-based strategy. This strategy scenario assumes that the labor can be improved by 25% due to the increase in labor supply or higher efficiency, the other constraints remain at the same or a lower than the original level.

4) Capital-based strategy. This strategy scenario assumes that the capital can be improved by 25% due to the increase in the capital supply. The other constraints remain at the same or less than the original level.

5) Balanced development strategy. The balance development strategy assumes that the farm land, non-farm land, labor and capital can be improved by 50%, 30%, 25% and 25%, respectively. These assumptions above will give evidence as to how much of the improvement for each sector or total can be improved by increasing the factor input.

This section uses the five scenarios to analyze the change of the new optimal levels of the last four scenarios with respect to the original Baseline level. To enhance the usefulness of the output to planners, it has been divided into six parts of the GPP, in terms of the value added, agricultural sector, energy sector, industry sectors, the services and household income.

4.2.1 The value added

The analysis on the value added includes the total GPP, VA-L.AG, VA-L.OR, VA-L.UR and VA-K with the Base-line, Land, Labor, Capital and Balance development strategies which can refer to the level and decomposition of GPP in value added terms in table 8.

Table 8. level and decomposition of GPP in value added terms

Sector	Baseline scenario 2002	Land-based scenario		Labor-based scenario		Capital based scenario		Balanced development scenario	
		New level	% change from baseline	New level	% change from baseline	New level	% change from baseline	New level	% change from baseline
Total GPP (in value added terms)	17,459,019	17,459,019	0%	20,010,247	15%	19,272,546	10%	21,823,774	25%
VA-L.AG	3,896,905	4,710,663	21%	4,251,237	9%	3,260,033	-16%	6,041,274	55%
VA-L.OR	1,823,314	1,588,099	-13%	2,458,322	35%	2,007,401	10%	1,940,916	6%
VA-L.U	4,484,693	3,906,149	-13%	6,046,581	35%	4,937,479	10%	4,773,950	6%
VA-K	7,254,107	7,254,107	0%	7,254,107	0%	9,067,634	25%	9,067,634	25%

Source: calculated by using the linear programming and the meso SAM

The Land-based scenario in table 8 shows that the total value added (GPP) does not enjoy any improvement between when there is 0% effect change in land productivity and when more efficient land use increase effective availability by 50% and 30% The Labor-based scenario indicates that the total value added (GPP) can be improved by 15% over the original level if either the labor supply or its efficiency increase 25%. The Capital-based scenario indicates that the total value added (GPP) can be improved by 10% compared to the Base-line situation if capital supply is increased by 25%.

The Balanced development scenario indicates that if farmland, non-farmland, labor and capital are simultaneously increased by 50%, 30%, 25% and 25%, respectively, this will bring about a 55%, 6%, 6%, and 25% improvement in the value added of agricultural labor, other rural labor, urban labor and capital. The total value added (GPP) can be improved by 25% compared to the simulated original situation in 2002.

4.2.2 Agricultural sector

In addition to these general results, we may analyze the optimal changes within each sector. The analysis of the agricultural sector includes 10 agricultural subsectors in terms of grain crops, beans, oil bearing crops, sugar crops, tobacco, other farming, forestry, animal husbandry, fishery and extension services. Table 9 summarizes the impacts of the Base-line, Land, Labor, Capital and Balanced development strategies on the optimal level of these activities.

The Land-based scenario in table 9 shows that if the amount of land supply or the efficiency of land use increases 50% and 30% on farm land and non-farm land; it will bring 993% and 502% increase in bean and forestry output compared to the original level. The Labor-based scenario indicates that if the amount of labor supply or the efficiency of labor increases 25%, it will bring 961% and 311% improvement in beans and forestry output. The Capital-based scenario indicates that if the amount of capital supply is increased by 25%, it will bring about a 338% and 123% gain in beans and forestry compared to the original level.

The Balanced development scenario indicates that if the farmland, the non-farmland, labor and capital separately increase 50%, 30%, 25% and 25% at the same period, it will bring 2080%, 460%, 3% improvement in beans, forestry and fishery to the original level. The balanced strategy suggests increasing specification in beans, forestry and fishery and decreasing the amount for other agricultural sectors.

4.2.3 Energy sector

The analysis of energy is based upon the impact of development strategies on energy sector activities (table 10).

All the strategies in table 10 show that, at the optimized level, the output of each energy sector will decrease. This strongly suggests that energy production in Yunnan is currently not efficient.

4.2.4 Industrial sector

The analysis of the industrial subsectors is based upon the impacts of development strategies on specific industrial sector activities (table 11)

The Land-based scenario shows that if the amount of land supply or the efficiency of land use increases 50% and 30% on farm land and non-farm land; it will bring about a 42% and 16% improvement in pesticides and timber and furniture to the original level. The Labor-based scenario indicates that if the amount of labor supply or the efficiency of labor increases by 25%, it will bring about a 34%, 22%, 8% and 2% improvement in timber and furniture, pesticides, papermaking, and textiles and apparel relative to the original level. The Capital-based scenario indicates that if the amount of capital supply is increased by 25%, it will bring about a 15%, 8% and 7% improvement in timber and furniture, pesticides, papermaking relative to the original level.

The Balanced development scenario indicates that if the farmland, the non-farmland, labor and capital simultaneously increase 50%, 30%, 25% and 25%, it will bring 62%, 45%, 6% and 1% improvement in pesticides, timber and furniture, papermaking, and textiles and apparel to the original level. These are thus the specific industrial sectors to be earmarked for future specialization for trade.

4.2.5 Services sector

The analysis of the services sectors includes 10 sectors in terms of construction, transportation and storage, telecommunication and logistics, retail and wholesale accommodation and restaurant, finance and insurance, tourism, scientific research, other services and public administration. Table 12 reports the impacts of the five scenarios on these sectors.

The Land-based scenario in table12 shows that if the amount of land supply or the efficient of the land use increase 50% and 30% in the farm land and non-farm land; it will bring a 758% and 12% improvement in finance and insurance and scientific research, respectively. The Labor-based scenario indicates that if the amount of labor supply or the, efficient of the labor increases by 25%, it will bring an 6781%, 652%, 12% and 8% improvement in telecommunication and logistics, finance and insurance, scientific research, and transportation and storage to the original level. The Capital-based scenario indicates that if the amount of capital supply is increased by 25%, it will bring about a 1177% and 11% improvement in finance and insurance, and scientific research, respectively.

The balanced development scenario indicates that if the farmland, the non-farmland, labor and capital separately is increased by 50%, 30%, 25% and 25% at the same period, it will bring an 998% and 14% improvement in finance and insurance, and scientific research, respectively. However, there will be a negative effect to the other 8 services sectors. The balance development strategy suggests increasing input on finance and insurance, and scientific research, and decreasing the input for other services sectors.

Table 9. The impacts of alternative development strategies upon agricultural sector activities

Sector	Baseline scenario 2002	Land-based scenario		Labor-based scenario		Capital based scenario		Balanced devel-opment scenario	
		New level	% change from baseline	New level	% change from baseline	New level	% change from baseline	New l evel	% change from baseline
Grain Crops	1,873,232	1,047,458	-44%	1,172,598	-37%	997,117	-47%	1,314,876	-30%
Beans	174,054	1,903,037	993%	1,846,365	961%	388,157	123%	3,794,387	2080%
Oil bearing Crops	70,071	39,182	-44%	43,863	-37%	37,299	-47%	49,185	-30%
Sugar Crops	254,815	142,485	-44%	159,508	-37%	135,637	-47%	178,862	-30%
Tobacco	654,940	366,223	-44%	409,976	-37%	348,623	-47%	459,721	-30%
Other Farming	1,618,071	904,779	-44%	1,012,873	-37%	861,295	-47%	1,135,771	-30%
Forestry	624,754	3,762,513	502%	2,568,747	311%	2,739,056	338%	3,500,323	460%
Animal husbandry	2,333,280	776,110	-67%	847,809	-64%	719,320	-69%	977,769	-58%
Fishery	173,837	144,721	-17%	172,226	-1%	149,630	-14%	179,249	3%
Extension services	526,541	72,592	-86%	69,630	-87%	50,406	-90%	98,595	-81%

Source: calculated by using the linear programming and the meso SAM

Table10. The impacts of alternative development strategies upon energy sector activities

Sector	Baseline scenario 2002	Land-based scenario		Labor-based scenario		Capital based scenario		Balanced development scenario	
		New level	% change from baseline	New level	% change from baseline	New level	% change from baseline	New level	% change from baseline
Coal mining and processing	576,096	261,091	-55%	300,185	-48%	245,958	-57%	330,247	-43%
Petroleum and natural gas extraction	1,884	1,464	-22%	1,718	-9%	1,443	-23%	1,824	-3%
Oil refining	1,169,719	562,371	-52%	1,093,230	-7%	574,136	-51%	679,464	-42%
Coking	111,495	53,744	-52%	57,635	-48%	46,608	-58%	67,400	-40%
Electricity and heat	1,934,615	910,213	-53%	1,115,244	-42%	931,840	-52%	1,124,962	-42%
Gas	64,319	48,638	-24%	66,338	3%	57,577	-10%	59,644	-7%

Source: calculated by using the linear programming and the meso SAM

Table 11. The impacts of alterative development strategies upon industrial sector activities

Sector	Baseline scenario 2002	Land-based scenario		Labor-based scenario		Capital based scenario		Balanced development scenario	
		New level	% change from baseline	New level	% change from baseline	New level	% change from baseline	New level	% change from baseline
Metal and non-metal mining	894,933	250,896	-72%	285,949	-68%	233,520	-74%	312,881	-65%
Food and tobacco processing	8,694,005	2,326,966	-73%	2,788,824	-68%	2,372,930	-73%	2,907,018	-67%
Textiles and apparel	792,379	644,714	-19%	807,926	2%	700,413	-12%	800,213	1%
Timber and furniture	334,848	387,844	16%	447,832	34%	384,242	15%	486,767	45%
Papermaking	1,152,615	1,033,147	-10%	1,244,866	8%	1,245,266	8%	1,225,784	6%
Fertilizer	713,443	551,468	-23%	532,102	-25%	425,029	-40%	698,457	-2%
Pesticides	61,916	87,631	42%	75,720	22%	66,305	7%	100,322	62%
Other chemicals	2,602,193	1,237,038	-52%	1,428,539	-45%	1,250,029	-52%	1,539,180	-41%
Metal and non-metal manufacturing	5,509,339	1,000,541	-82%	1,191,929	-78%	960,924	-83%	1,240,111	-77%
Equipment	2,170,626	690,364	-68%	956,131	-56%	701,863	-68%	828,326	-62%
Machinery	577,562	256,678	-56%	305,621	-47%	269,532	-53%	311,373	-46%
Electronics, instruments, and office equipment	804,112	563,802	-30%	674,573	-16%	589,768	-27%	696,002	-13%
Other manufacturing	116,276	54,089	-53%	64,954	-44%	56,510	-51%	66,511	-43%
Waste	185,766	185,766	0%	114,737	-38%	185,766	0%	185,766	0%
Water	132,421	100,264	-24%	146,634	11%	109,452	-17%	124,447	-6%

Source: calculated by using the linear programming and the meso SAM

Table12. The impacts of alterative development strategies on service sector activities

Sector	Baseline scenario 2002	Land-based scenario		Labor-based scenario		Capital based scenario		Balanced development scenario	
		New level	% change from baseline	New level	% change from baseline	New level	% change from baseline	New level	% change from baseline
Construction	6,577,225	162,495	-98%	214,877	-97%	160,451	-98%	199,176	-97%
Transportation and storage	2,252,151	1,109,136	-51%	2,426,420	8%	1,072,701	-52%	1,347,564	-40%
Telecommunication and logistics	96,169	65,941	-31%	6,617,869	6781%	71,546	-26%	81,645	-15%
Retail and wholesale	3,387,126	1,615,864	-52%	1,958,826	-42%	1,584,898	-53%	2,012,106	-41%
Accommodation and restaurant	1,359,906	940,691	-31%	1,146,056	-16%	1,054,433	-22%	1,114,983	-18%
Finance and insurance	1,153,100	9,898,836	758%	8,676,631	652%	14,726,614	1177%	12,664,033	998%
Tourism	205,193	42,388	-79%	59,159	-71%	51,161	-75%	51,803	-75%
Scientific research	524,295	585,136	12%	589,232	12%	581,376	11%	595,995	14%
Other services	7,081,294	3,874,536	-45%	4,570,701	-35%	4,723,773	-33%	4,782,803	-32%
Public administration	2,898,829	2,905,148	0%	2,906,490	0%	2,905,167	0%	2,905,446	0%

Source: calculated by using the linear programming and the meso SAM

4.2.6 Household income

The analysis on the household sectors includes 5 rural sectors (RH1, RH2, RH3, RH4, RH5) and 7 urban sectors (UH1, UH2, UH3, UH4, UH5, UH6, UH7). Table 13 reports the impact of choosing each of the 5 development on the level and share of income among these 12 classes.

The Land-based scenario in table13 shows the land strategy does not work well for improving household income. If the amount of land supply or the efficiency of the land use increases by 50% and 30% in the farm land and no-farm land, it will only result in an 5%, 3% and 1% improvement in RH3, RH4 and RH5. But it will be accompanied by a stronger negative effect on the rest 9 household sectors. The total rural household income is increased by 2% and the total urban household income is decreased by 17%. The "scissors" ratio of per capita rural to urban incomes is 30%, which is bigger than original level 24%. Compared to the original simulated level, the total income to poorest households decrease 10%; the total income to richest households decrease 3%. The quintile ratio top 20 to bottom 20 % is 3 times.

The Labor-based scenario indicates that the Labor-based strategy works very well for improving all household income. If the amount of labor supply or the efficiency of labor increases 25%, the labor strategy does work well for improving the household income for all the types of household between 5% and 26%. However, RH1, the poorest rural household, can not be improved. The total rural household income increases by 8% and the total urban household income increases by 22%. "Scissors" ratio of rural to urban incomes per capita is 22% which is less than original level 24%. Comparing the original level, the total income to poorest households increases by 6%; the total income to richest households increases by 18%. The quintile ratio top 20 to bottom 20 % is 3 times.

Table13. The impacts of alternative development scenarios on the distribution of income										
		Land-based scenario		Labor-based scenario		Capital based scenario		Balanced development scenario	
Sector	Baseline scenario 2002	New level	% change from baseline	New level	% change from baseline	New level	% change from baseline	New level	% change from baseline
RH1	856,223	815,421	-5%	854,609	0%	770,674	-10%	1,029,649	20%
RH2	1,055,636	1,048,106	-1%	1,104,250	5%	953,961	-10%	1,324,994	26%
RH3	1,269,540	1,287,712	1%	1,360,218	7%	1,149,681	-9%	1,628,832	28%
RH4	1,529,602	1,580,041	3%	1,672,623	9%	1,387,723	-9%	1,999,558	31%
RH5	2,344,075	2,467,783	5%	2,618,159	12%	2,130,770	-9%	3,124,533	33%
UH1	273,681	221,521	-19%	307,779	12%	279,109	2%	272,519	0%
UH2	336,516	276,855	-18%	396,085	18%	349,121	4%	340,012	1%
UH3	844,626	695,926	-18%	998,256	18%	877,647	4%	854,549	1%
UH4	1,100,059	910,584	-17%	1,316,691	20%	1,148,626	4%	1,117,600	2%
UH5	1,290,010	1,082,029	-16%	1,600,081	24%	1,365,798	6%	1,326,219	3%
UH6	732,663	620,044	-15%	930,470	27%	783,002	7%	759,285	4%
UH7	953,674	805,032	-16%	1,203,062	26%	1,016,479	7%	986,070	3%
Total increase in rural incomes	-	143,988	2%	554,784	8%	-662,266	-9%	2,052,491	29%
Total increase in urban incomes	-	-919,238	-17%	1,221,194	22%	288,552	5%	125,023	2%
"Scissors " ratio of rural to urban incomes per capita	24%	30%		22%		21%		31%	
Total income to poorest households	1,466,419	1,313,797	-10%	1,558,473	6%	1,398,904	-5%	1,642,180	12%
Total income to richest households	4,030,412	3,892,859	-3%	4,751,691	18%	3,930,250	-2%	4,869,888	21%
Quintile ratio top 20 to bottom 20 %	3	3	-	3	-	3	-	3	-

Source: calculated by using the linear programming and the meso SAM

The Capital-based strategy favors urban over rural households. If the amount of capital supply increased 25%, it would improve urban household incomes between 2% and 7% but decrease rural household incomes between 9% and 10% for each type of household. The total rural household income decreases 9% while total urban household income increases 5%, making the "scissors" ratio of rural to urban incomes per capita reduce to 21% from the original level of 24%. Comparing the original level, the total income of the poorest households decreases by 5%; the total income to richest households decreases by 2%. The quintile ratio top 20 to bottom 20 % is 3 times.

The Balanced development scenario indicates that a balanced strategy works well both for rural and urban households. Noticeably, rural household income gets improved to a greater extent, closing the urban-rural income scissor gap. If farmland, non-farmland, labor and capital increase by 50%, 30%, 25% and 25%, respectively at the same period, it will improve the urban household income between 1% and 4% and the rural household income between 20% and 33% for each type of household. The total rural household income increase 29% and the total urban household income increase 2%. The "scissors" ratio of rural to urban incomes per capita will rise to 31% from its original level 24%. Compared to the Baseline simulation, total income to the poorest households increases 12%; the total income to the richest households increases 21%. As a result, the quintile ratio of the top 20% to the bottom 20 % triples.

05. Conclusions and recommendations

We can conclude by answering the research questions of this article as following:

- If the overall development priority of Yunnan government planners is to maximize the GDP of the Yunnan economy as measured by total value added, the agricultural sectors like beans, tobacco, sugar crops, other farming, forestry animal husbandry oil bearing crops, grain crops, waste, fishery, finance and insurance, telecommunication and logistics, accommodation and restaurants should be targeted for exogenous investments from government, banks, the rest of China and the foreign sector.
- If, on the other hand, the overriding policy priority is to minimize environmental degradation caused by economic activity in Yunnan, the textiles and apparel, electric, instrument and office equipment, other manufacturing, equipment, machinery, food and tobacco processing, agricultural extension services, finance and insurance, retail and wholesale marketing, timber and furniture, and fisheries should be earmarked for the exogenous investments from government, bank, the rest of China and the foreign sector. On the contrary, such sectors as papermaking, other chemicals, coking, coal mining and processing, accommodation and restaurant, pesticides, petroleum and natural gas extraction, waste, oil refining fertilizer should be limited for the environmental consideration.
- If, instead, the overall planning objective is to minimize the energy dependency of then Yunnan economy, then waste, electric, instrument and office equipment, textile and apparel pesticide, food and tobacco processing, other manufacturing, finance and insurance, other services, papermaking, equipment etc. should be targeted for the exogenous investments from government, bank, the rest of China and the foreign

sector. At the high end of the energy spectrum, such sectors as electricity and heat, gas, coking, coal mining and processing, oil refining, fertilizer, metal and non-metal mining, transportation and storage, papermaking, other chemicals, coking, coal mining and processing, accommodation and restaurants, pesticides, petroleum and natural gas extraction, waste, oil refining fertilizer should be limited.

- If development targeting aims to make the fullest use of the net transportation infrastructure of Yunnan economy, transportation and storage, tourism, metal and non-metal mining, telecommunication and logistics, construction, metal and non-metal manufacturing, fertilizer, forestry, grain crops, oil bearing should be targeted for the exogenous investments from government, bank, the rest of China and the foreign sector.
- If promoting the greatest potential for increasing employment of Yunnan economy is the goal, then all agricultural sectors, telecommunications and logistics, accommodation and restaurant, water, finance and insurance, transportation and storage should be promoted for exogenous investments from government, bank, the rest of China and the foreign sector.
- If, instead, the overriding concern of economic planners is to close the rural urban income scissors ratio and other measures of poverty as much as possible, all agricultural sectors, accommodation and restaurant, telecommunication and logistic, finance and insurance, timber and furniture, water, metal and non-metal mining, food and tobacco processing etc. should be targeted for the exogenous investments from government, bank, the rest of China and the foreign sector.
- Labor is the most binding constraint to future increases in value added GDP Specifically, increasing the efficiency or the supply of labor will bring about a 15% improvement in the VA.
- No sector of the economy occupies the top rank across all types of multiplier in terms of value added, employment creation, environmental degradation, energy dependency, poverty alleviation, full use of transportation. However, some sectors do score substantially higher in most of the multiplier ranks. All agricultural sectors, telecommunication and logistics, finance and insurance, food and tobacco processing, timber and furniture. If planners wish to purpose multiple-objective all-round planning, these are the sectors in which to invest through government activities directly and or through joint ventures with banks, the private sector, and foreign and overseas Chinese entrepreneurs.

- Reassuringly, the linear program and the integrated multiplier show almost the same results: that investment should be increased in beans, forestry, timber and furniture, finance and insurance and scientific research. There is thus no contradiction between the multiplier and linear programming approaches. However, the latter is necessary to quantify the exact scale of each branch under optimal 5-year plans.
- According to the results dictated by the balanced linear programming scenario, government policies should be most favourable to increasing investment in the beans (2080), forestry (460), and finance and insurance (998).

Based on the study results, and under the assumption that the patterns and potentials inherent in the 2002 SAM have not shifted significantly, we suggest for Yunnan Province's future development that:

- Agricultural structural adjustment should be pushed toward the sectors which have higher economic benefits; meanwhile, more exogenous investment should be invested into agriculture, particular in bean, forestry, timber and furniture.
- Finance and insurance services should be increased and improved by favourable policy to satisfy increasing of market demand
- Telecommunications and logistics services should be increased and improved to promote the circulation of the commodities, services and information.
- The scale and volume of polluting enterprises be restricted or reduced.
- Investment on the low energy dependency sectors be encouraged while that in high energy dependent sectors is reduced.

Investments in infrastructure such as superhighways, bridges, and airports be continuously increased so that the globalization and export potential of the province can keep pace with the expansion of the output of sectors identified to have competitive advantage.

06. Further studies, applications, or extensions of the research

In terms of further research, it is recommended that the current study be updated as soon as possible with the latest 2007-based data; and that companion optimization and SAM studies be conducted in the other provinces of China. This will be particularly helpful in the disadvantaged Western provinces of the country, where government must still act as a Big Leader[6] to guide the way for private and overseas investments. Although the present research sheds new light on an overview of the Yunnan economy, there are still some purposes of research can not be achieved by this article. Since there was a publishing lag of 7 years in the data, the empirical results based may differ somewhat (on the assumption that the economic structure will maintain highly similar or dramatically) due to the sharply change in both economic scale and structure of the economy. Therefore, it may be interesting for the future research to consider updating the new SAM once a new I-O table has been published, and to continuously monitor the economic structural change thereafter. Nor can some research topics related to agriculture, transportation, energy, employment, pollution and poverty be explored in-depth based in a single article. Moreover, the trade with the rest of China and with foreign countries (notably those in Southeast Asia) is a very pertinent topic beyond the scope of this article. Finally, based upon the meso SAM develop for this research, a CGE model of the Yunnan economy could be constructed to carry out policy analysis.

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6 *This expression is taken from Robert Wade. 1988, Governing the Marketing.*

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