The Economic Journal of Nepal
Vol. II, No. 2. April 1979 EIC-TU

A Mathematical Framework of the Sixth Five Year Plan of Nepal

(An Alternative Model)

– Prithvi Raj Ligal*

I

Nepal is in the terminal year of its fifth five year plan. A draft sixth five year plan had been circulated by National Planning Commission in the eighth annual meeting of National Development Council in September 1978.

However, at present NPC must be revising it on the basis of the latest available data, hence it seems to be the appropriate time to work out some alternative numerical models of the sixth plan.

The main purpose of this paper is two-fold.

(i) To develop simple mathematical framework of the sixth plan, and

(ii) To test the model thus developed, with some alternative numerical values of the parameters taking different variables as given and to suggest the most appropriate one.

In fulfilling the above mentioned objectives the paper has been divided into the following parts.

Part II will examine the calculation of desired investment and the basic model for the sixth plan that NPC had adopted.

*Mr. Ligal is a member of the Economics Instruction Committee, Kirtipur Multiple Campus, Tribhuvan University.

Part III discusses the mathematical framework or model developed to test sixth plan.

Part IV examines first the model with numerical values of the parameter in the sixth plan and then goes to examine it with alternative numerical values of the parameters assuming different variables as given.

Lastly part V discusses the main findings of the paper.

II

Nepal started planned development in 1966. But it seems, she has not adopted any planning model as such in her development plans till now. Even in formulating the current sixth five year plan it has not adopted any formal planning model, but one can very well see that the required investment to achieve the target growth rate explicitly mentioned in the objective of the plan are worked out on the basis of the famous Harrod–Domar growth model form.

$$\frac{\triangle Y}{Y}=\frac{\triangle S/\triangle Y}{B} \qquad \text{Since} \qquad S/Y=I/Y \text{ (Assumption made in the model)}$$

$$\frac{\triangle Y}{Y}=\frac{I/Y}{B} \qquad =I/Y \;=\; 1/B$$

$$\therefore \triangle Y=1/B.\ I$$

Where, Y=Desired increase in income over the plan period which is based on the target rate of growth of the plan.

I=Desired volume of invsetment.

B=Global ncremental capital output ratio.

Current draft sixth five year plan fixes a 5.1% rate of growth per annum and

B=3.8325

Projected GDP at 1979/80=Rs 22247 m.

GDP at 1984/85 $=22247\ (1+0.051)^5$

=Rs 28535.4 m. (constant 1979/80 price)

$\triangle Y$=GDP 1984/85 – GDP 1979/80

=28525.4 – 22247=Rs. 6288.4 m. Required investment over the plan period,

I=Rs 6288.4×3.8325

=Rs 24100 m.

Which comes to be around 18.6% of the GDP. And allowing a margin of 18.1828% NPC has estimated a sum of Rs 28000 million to spend over the planning period.

III

The type of model used here is the type of decision model used by Pant–Little in checking the consistency of the perspective exercises carried out by the perspective planning division of the planning commission of India in its third plan, and by S. Chakravarty and P. N. Rosenstien–Rodan in developing some alternative numerical model of the third plan of India.

Decision model implies that it must necessarily have more unknowns than equations, that is the system must possess certain "degrees of freedom". In such type of decision model, the number of 'degrees of freedom' gives planners, the number of variables which they can set arbitrarily from outside and the remaining variables is determined from within the system. This gives number of alternative policy constellations from which a choice may be made. Pant and Little used fifteen variables with thirteen equations i. e. with two degrees of freedom and they used investment and foreign aid as given from outside. Chakravarty and Rosenstien–Rodan on the other hand test it with alternative numerical values taking two different variables as exogenous.

The model used here is a linear equation expressed in terms of a set of algebriac equations in which only the initial and final values are related. It is concerned with a period of five years. The model used is :

$$I=\sum I_t \quad =\sum s_t \quad +F \qquad \ldots \ldots \ldots \quad (1)$$

$$\Delta Y=\frac{1}{B}.I \qquad \ldots \ldots \ldots \quad (2)$$

$$\sum s_t=s_0+t.\alpha \qquad \ldots \ldots \ldots \quad (3)$$

$$DAg\,(t)=P^t\,(Y/P)^n_t \qquad \ldots \ldots \ldots \quad (4)$$

$$\Delta YAg \quad =\frac{1.\,IAg}{BAg} \qquad \ldots \ldots \ldots \quad (5)$$

$$E=(1+r_1).I \qquad \ldots \ldots \ldots \quad (6)$$

$$\Delta YA_g \; +YNA=\Delta Y \qquad \ldots \ldots \ldots \quad (7)$$

$$IA_g \; +INA=I \qquad \ldots \ldots \ldots \quad (8)$$

$$\Delta C_t \; +\Delta S_t \; =\Delta Y_t \qquad \ldots \ldots \ldots \quad (9)$$

$$\Delta DA_g \; =\Delta YA_g \qquad \ldots \ldots \ldots \quad (10)$$

In this model, the endogenous valablues used are :

1. I=Total investment
2. st=Saving in period t
3. F=The amount of net foreign aid plus loan.
4. $\wedge$Y=The increase of income over the five year period.
5. DAg=Demand for agricultural production.
6. $\triangle$YAg=Increase in agricultural production.
7. E=Total plan outlay
8. $\triangle$YNA=Increase in non-agricultural production.
9. C_t =Consumption in period "t"
10. IAg =Investment in agriculture.
11. INA=Investment in non-agricultural.
12. $\gg$ =The annual increment in saving.

And the data of the system in other words the exogenous variables are:

1. pt =Population in year "t"

The paremeters used are :

1. B : The global incremental capital output ratio.
2. BAg : The incremental capital-output ratio in agriculture.
3. n : The income elasticity of demand for agricultural production.
4. r_1 : Margin allowed to increase I in %

Thus, we have altogether (12) unknowns and (10) equations. Of these (10) equations, (1), (7), (8) are either definitional or balance equations while equations (3), (4) are behavioral equations, rest shows technological equation and equilibrium conditions; we have 12 endogenous variables and 10 equations to determine those variables in the model, we thus have two degrees of freedom.

The values of any two variables may therefore can be set arbitrarily from outside and the rest can be determined from within the system. This gives of a number of alternative policy constellations from which a choice may be made.

Regarding the structural equations in the above model, the following explanations may be given,

1. Total investment for the whole period is given by total savings in the period concerned plus net foreign aid and loans etc.

2. Following Harrod-Domar, increase in income over the period is given by investment in the period divided by the incremental capital output ratio.

3. Savings at time "t" is a increasing function of time "t"

4. Demand for agricultural production at "t" is a function of level of population at "t" and per capita income at "t". This can be more meaningfully represented in incremental form as follows:

$$\frac{DA_g\ (t)}{DA_g\ (t)} = \frac{P_t + n}{P_t} \quad \frac{(Y/P)t}{(Y/P)t}$$

In other words, relative rate of increase in the demand for agricultural production is the sum of the relative rate of increase in population plus the relative rate of increase in per capita income multiplied by the income elasticity of demand for agriculture.

5. Increase in agricultural income over the period is given by investment in agriculture over the period divided by increased capital–output ratio in Agricultural sector.

6. Total plan outlay is equal to the desired plan investment multiplied by the margin allowed to increase.

7. Total increase in income over the period is composed of increase in agricultural income plus increase in non–agricultural income over the same period.

8. Total investment composed of total agricultural investment plus total non–agricultural investment.

9. Increase in current income over the period is balanced with increase in current consumption plus increase in current saving; and

10. Increase in the demand for agricultural production equals increase in agricultural income over the same period,

IV

As already shown in part II we have two degrees of freedom in the model which means we can choose any two of the variables as given (exogenous).

Looking at the draft sixth plan the exogenous variables given are

1. $\triangle Y$ Which is derived from the target rate of growth.
2. F Derived as a difference between total investment required and total govt. revenue. In this case I will be determined as consequence from the technological equation (2).

Now the numerical illustration assumed in the plan are

(i) Initial values (1979/80)

YO = Rs 22247 m.

SO = Rs 1779.8 m.

(ii) Exogenous variables:

F = Rs 11600 m. (max.)

$\triangle Y$ = Y 1984/85 = Rs 6288.4 m.

$\therefore$ I = $\triangle Y$ .B = 6288.4×3.8325

= Rs 24100 m.

(iii) N = 0.7723

B = 3.8325

As an initial value savings (so) at 1979/80 is calculated on the basis of the linear consumption function fitted for the economy with a historical data. Regarding foreign oid etc. since no mention has been explicitly made in the draft plan, the total amount of Rs. 11600 m. has been taken as total net foreign aid plus loan for the initial NPC model. The value of the parameter r_1, is taken as a margin of 16.1828% as calculated by NPC.

Derivation of values of other variables :

$I = \Sigma I_t = \Sigma S_t + F$

$\Sigma S_t = I - F = 24100 - 11600 =$ Rs 12500 m.

$\Sigma S_t = 550 + 15 \propto$

$\therefore \propto = 240.0667$

$\therefore S_5 =$ Rs 2980.13 m. (10.44% of GDP)

$$\therefore \quad \triangle S = S_5 - SO = 2980.13 - 1779.8$$

$$= \text{Rs } 1200.33 \text{ m.}$$

$$\frac{\triangle S}{\triangle Y} = \frac{1200.33}{6288.5} = 19.09\ \% \text{ per annum}$$

Income elasticity of demand for agricultural production is derived from using historical data as n = 0.7723

That is if the amount of foreign aid plus loan is taken as mentioned above then the value of the marginal propensity to save will have to raise from 9.1% in the initial period to 19.09% during the plan period.

$$\triangle C = \triangle Y - \triangle S = 6288.4 - 1200.33$$

$$= \text{Rs } 5088.1 \text{ m.}$$

$$\therefore \quad \frac{\triangle C}{C} = \frac{\triangle Y - \triangle S}{Yo - So} = \frac{1200.33}{20467.2} = 24.86\%$$

It shows that the rate of growth of counsumption per annum is 4.54%. Assuming population to increase at a rate of 2.2% per annum, per capita national income will increase by (4.54–2.2) = 2.34% per annum.

Increase in the demand for agricultural production is given by,

$$\frac{\triangle DAg}{DAg} = 2.2\% + 0.7723 \times 2.9\%$$

$$= 0.022 + 0.7723 \times 0.029$$

$$= 0.0444$$

or 4.44 % per annum during the plan period. Thus agriculture production must increase by 4.44 % annualy (sixth plan assumes to increase it by 5.22% annually), which means for a 5.1% grtwth in GDP annually. Production in non–agricultural sector must increase by 5.86% per annum (sixth plan assumes only 4.96% increase in non–agricultural sector).

∴Required investment in agricultural sector to achieve 5.23% annual increase assumed in the plan is

$$IAg = BAg \cdot YAg$$

$$= 2 \times 3168.5$$

$$= \text{Rs } 7737 \text{ m.}$$

And non-agricultural investment equals

$$INA = I - IAg = 24100 - 7737$$
$$= \text{Rs. } 16363 \text{ m.}$$

Alternative numerical model

In this model three cases are taken, viz;

(i) CASE A
- (a) rate of growth/ annum, g = 5.1%
- (b) F = Rs. 7000 m.
- (c) ICOR = 4.384: 1
- (d) BAg = 4: 1

(ii) CASE B
- (a) F = Rs. 6000 m.
- (b) ICOR = 4.25% : 1
- (c) BAg = 4:1
- (d) S/Y = 10.39%
- (e) g = 3.58%

(iii) CASE C
- (a) F = Rs 7000 m.
- (b) ICOR= 4.25:1
- (c) BAg = 4:1
- (d) S/Y = 9.58%
- (e) $\triangle S/\triangle Y$= 23.08%
- (f) g = 3.58%

Case A is actually a variation of the original NPC model. Only the values of global incremental capital output ratio, agricultural incremental capital output ratio, and the amount of foreign aid etc. has been changed.

In case B, value of B has been slightly decreased to 4.25%:1, the amount of foreign aid to Rs. 6000 m. and average saving ratio as 10.39%. Rate of growth has been decreased to 3.58% per annum.

In case C the amount of foreign aid has been increased to Rs 7000 m. and S/Y ratio to 9.57%.

The results of all these models are shown in the following tables. In all the three

AITERNATIVE NUMERICAL MODELS OF THE SIXTH PLAN (1980/85)

	NPC	MODEL A	MODEL B	MODEL C
	ICOR: 3.8325 : 1 $\Delta S/\Delta Y$: 19.09% S/Y : 9.65 %	ICOR 4.384 : 1 $\Delta S/\Delta Y$=43.47% S/Y =15.89%	ICOR 4.250 : 1 $\Delta S/\Delta Y$=30.88% S/Y =10.39%	ICOR 4.25 : 1 $\Delta S/\Delta Y$=23.08% S/Y =9.58%
A. 1. GDP Ist year in m. Rs	22247	22247	22247	22247
2. GDP 5th year in m. Rs	28535.4	28535.4	26524.7	26524.7
3. Increase in GDP over 5 years in m Rs	6288.4	6288.4	4277.7	4277.7
4. Rate of growth per annum	5.1 %	5.1%	3.58%	3.58%
B. 1. Domestic savings 1st year in m. Rs	1779.8	1779.8	1779.8	1779.8
(% of GDP)	(80%)	(8.%)	(8%)	(8%)
2. Domestic savings 5th year in m. Rs	2980.13	4513.5	3100.6	2767.3
(% of GDP)	(10.44%)	(15.82%)	(11.69%)	(10.43%)
3. Total domestic savings over 5 years in m. Rs	12500	17100	12861.5	11861.5
(% of GDP)	(9.65%)	(13.21%)	(10.39%)	(9.58%)
C. 1. Consumption in 1st year in m. Rs	20467.2	20467.2	20467.2	20467.2
2. Consumption in 5th year in m. Rs	25555.3	24021.9	23424.1	23763.4
3. Increase in consumption over	5088.1	3554.7	2956.9	3296.2
5 years (in %) in m. Rs	(24.86%)	(17.37%)	(14.45%)	(16.10%)
4. Rate of Increase	4.54%	3.25%	2.74%	3.03%
5. Per capita rate of increase	2.34%	1.05%	0.54%	0.83%

D. 1. Agricultural production in 1st year in m. Rs	13346	13346	13346	13346
2. Agricultural production in 5th year in m. Rs	17214.5	17124.5	15675.5	15675.5
3. Increase in agricultural production in m.Rs (Assumption of income elasticity of agricultural demand=0.7723)	3868.5 (5.22%)	3868.5 (5.22%)	2329.5 (3.27%)	2329.5 (3.27%)
E. 1. Non-agricultural production in 1st year in m. Rs	8901	8901	8901	8901
2. Non-agricultural production in 5th year in m. Rs	11320.9	11320.9	10849.2	10849.2
3. Increase in non-agricultural production in m. Rs	2419.9 (4.93%)	2419.9 (4.93%)	1948.2 (4.04%)	1948.2 (4.04%)
F. 1. Foreign aid etc. in m. Rs (% of Total plan outlay)	11600 (4.43%)	7000 (25.0%)	6000 (27.38%)	7000 (31.94%)
G. 1. Investment in agricultural sector in m. Rs	7737	15474	9318	9318
2. Investment in non-agri. sector in m. Rs	16363	8626	9543.5	9543.5
3. Total investment in m. Rs (% of GDP)	24100 (18.61%)	24100 (18.61%)	18861.5 (15.22%)	18861.5 (15.22%)
H. ICOR in agricultural sector	2:1	4:1	4:1	4:1
I. Total plan outlay in m. Rs (allowing a 16.1828% margin) (% of GDP)	28000 (21.63%)	28000 (21.63%)	21913.8 (17.71%)	21913.8 (17.71%)
J. Rate of growth of population per annum	2.2%	2.2%	2.2%	2.2%

models, foreign aid plus loans has been taken as Rs 6000 m. (27.38% of the total plan outlay) or Rs 7000 m. (31.94% of the total plan outlay). In absolute amount this comes to be more than double of the maximum amount expected in the fifth plan. Though we can't predict the exact amount of foreign aid plus loan, yet if we look over the past trend of foreign aid plus loan actually received, the figure (Rs 6000–7000 m.) seems to be the maximum obtainable.

Regarding global incremental capital output ratio model B and C assumes the va lue 4.25 :1. It is because of two factors, viz;

(a) The value of the incremental capital output ratio in Nepal is in decreasing trend, and

(b) There are a lot of unutilized productive capacity in the industrial sector in Nepal.

Due to these factors it will be safer to assume a 4.25 : 1 as the value of the imcremental capital output ratio in Nepal.

A high S/Y and a high $\triangle S / \triangle Y$ figure seems not feasible, when we look at the mass poverty and other striking features of the country. Moreover due to the heavy dependence on foreign aid etc. and alarmingly increasing volume of imports makes it not to think a high S/Y and $\triangle S / \triangle Y$ ratio. The negative relationship between domestic savings, and net foreign capital inflow as shown (in the notes) supportsht our hypothesis. During the coming six. plan period too the increasing trend of import and the heavy dependence on foreign aid will continue. Import will increase more rapidly in the coming years due to increases of further expected increase in oil price etc. So S/Y and $\triangle S/\triangle Y$ will change gradually in the coming years. Therefore it seems to be safer enough to assume S/Y=9.58% and $\triangle S/\triangle Y$=23.08% during the sixth plan period.

Summary and Conclusion:

Using Pant—Little, Chakravarty—Rodan type of decision model some alternative numerical models has been shown here for the coming sixth five year plan of Nepal. In determining the values of the basic parameters empirical studies are done as far as practicable. This makes the values of the basic parameters more realistic, but however due to the unreliable nature of the existing available data the model thus developed may be taken as suggestive rather than conclusive.

Out of the three alternative model shown, model C seems to be more realistic which assumes S/Y=9.58% and $\triangle S/\triangle Y$=23.08% with Rs 7000 m. (31.94% of total plan outlay) and Rs21913.8 m. (17.71% of GDP) total plan outlay generating 3.58% per annum as the growth rate.

Notes and reference:

— NPC : Basic principles of the sixth plan (1980/85), 1979, HMG/N.

— S. Chakravarty : The Mathematical framework of the third five year plan, in P.N. Rosenstein—Rodan (ed.) "Capital Formation and Economic Development." 1965, George Allen and Unwin Ltd. London.

— P.N. Rosenstein-Rodan : "Alternative Numerical Models of the Third Five Year Plan of India" in P.N. Rosenstein–Rodan (ed.); "Capital Formation and Economic Development", 1965, George Allen and Unwin Ltd. London.

— The Income Elasticity of demand for agricultural production is derived from the following regression using historical data (1964/65–76/77) at constant 1976/77 price.

$$\ln YAg = 1.8179 + 0.7723 \ln Y$$

$$(1.8270)^{*} \quad (7.4567)^{**}$$

$$\bar{R}^2 = 0.8361$$

$$F = 50.9718$$

$$\text{Elasticity, } n = \frac{d \ln YAg}{d \ln Y} = 0.7723$$

The figures in paranthesis are the t—value *significant at 90% confidence level.

**Significant at 99% confidence level, elasticity, $\bar{R}^2$ gives corrected $\bar{R}^2$.

— S/Y ratio is calculated from the following regression equation, using historical data (1964/65–76/77) at constant 1976/77 price.

$$C_t = 781.1194 + 0.8866\, Y_t$$

$$(13.3878)^{*} \quad (14.2083)^{**}$$

$$\bar{R}^2 = 0.9675, \quad F = 358$$

Figures in the parenthesis shows t—value significant at 99% confidence level. For 1979/80 (Assuming the validtity of the equation)

We have,

$$C/Y = 0.9217$$

We have,

$$S/Y = 1 - C/Y = 1 - 0.9217 = 0.0783$$

or, $S/Y = 7.83\%$. It comes to be exactly same (7.9% for 1979/80) as NPC assumed in its 5th Plan–Review of Eco. Situation of Nepal, 1976, World Bank Report No. 1180–NEP.

Roughly, here the intial value for S/Y is taken as 8 %.

— Global incremental capital–output ratio is calculated from the following regression using historical data from 1964/65–76/77 at constant 1976/77 price.

$$Y_t = \underset{(23.8823)}{13156.7023} + \underset{(4.0372)}{0.2281} \sum_{i=o}^{i=t-1} Ii$$

$$\bar{R}^2 = 0.9440 \; ; \; F = 186.5$$

$$ICOR = \frac{1}{0.2281} = 4.3840$$

t–value significant at 99% confidence level.

— Incremental capital output ratio in agricultural sector is calculated from the following regression using historical data (1964/65–76/77) at constant 1976/77 price.

$$YA_g = \underset{(48.6305)}{9376.1818} + \underset{(5.7925)}{0.2475} \sum_{i=o}^{i=t-1} IAgi$$

$$\bar{R}^2 = 0.7284$$

$$F = 30.5$$

$$ICOR, BAg = 4.0404$$

t–value significant at 99% confidence level.

— Rate of growth is calculated by using following type of formula

$$r = \left(\frac{Y_t}{o}\right)^{\frac{1}{t}} - 1$$

Where, Y_t and Y_o shows current and base year value, t for time and r for rate of growth.

— Regression of average savings to average foreign capital in-flow in Nepal (1964/65–76/77) gives following results

$$S/Y = 0.1208 - 0.6852\ F/Y$$
$$(10.6434)\ (3.4689)$$
$$\bar{R}^2 = 0.4736 \quad F = 11.8$$

The result shows negative relationship between domestic savings and net foreign capital inflow in Nepal. It may be because foreign capital inflow in Nepal induces people more to spend. Detailed discussion of it will be presented on the author's forthcoming paper.

— Report on "Industrial survey—2034" prepared by Nepal Rastra Bank, reveals that at an average only 52% of the total capacity of the existing industries in the country are used in some cases the capacity utilization are even as low as 14% of the capacity. It clearly shows the present large unutilized capacity available in the industrial sector.

— For Detailed discussion regarding global and agricultural incremental capital output ratio see author's "A note on capital output ratio in Nepal" (forthcoming).

— Relevant data were collected from NPC, CBS, NRB publications and author's own calculation.