Discussion Paper Series No. 18

NCAER

Oil Price Shock and Poverty in a CGE Framework

Basanta K. Pradhan
Amarendra Sahoo

The Discussion Paper Series comprises preliminary documents circulated in a limited number to stimulate discussion and critical comment.

National Council of Applied Economic Research
11, I.P. Estate, New Delhi 110 002
Fax: (91-11) 337 0164, Tel.: (91-11) 337 9861–3
www.ncaer.org

Discussion Paper Series No. 18

Oil Price Shock and Poverty in a CGE Framework

Basanta K. Pradhan
Amarendra Sahoo

Abstract

A 23-sector, 3-factor and 9-household group computable general equilibrium (CGE) model with neo-classical closure has been used to analyse the impact of international oil price shock on the welfare and poverty of socio-economic household groups. A sensitivity analysis has been carried out to look into the impact of change in the elasticity of substitution between imports of crude oil and domestically produced oil on the household groups.

JEL Classification: C68, E30, I30
Keywords: CGE model, oil price shock, poverty, welfare

This paper forms a part of the MIMAP–India Project funded by the International Development Research Centre, Canada. A previous version of this paper was presented at the MIMAP Training Programme, held at Manila, Philippines, during 28 Feb.–9 Mar. 2000.

Published by
Narinder Sapra, Registrar & Secretary
National Council of Applied Economic Research
Parisila Bhawan, 11, Indraprastha Estate
New Delhi 110 002
www.ncaer.org

Printed at
Innovative Processors
4819/24, Ansari Road
New Delhi 110 002
Tel.: 325 2537

Contents

Oil Price Shock and Poverty in a CGE Framework

1. Introduction

In the recent period, many developing economies have faced a series of international oil price shocks. International crude oil price shot up from a monthly average of around $10 per barrel in February 1999 to a 10-year high of $37.28 per barrel in September 2000. Crude oil has been one of the most essential inputs for the industrial production in the Indian economy. Large dependence on its import increases its importance in the economy further. According to the 1998–99 import statistics, the import of crude petroleum constitutes around 15 per cent of the total imports and 49 per cent of the bulk imports in India. A spurt in crude oil price has affected the economy in many ways: changing prices and output, and ultimately having an impact on the income of households and, hence, on their welfare and poverty. An attempt is made to capture the impact of this shock on the poverty and welfare of households through a computable general equilibrium (CGE) model. The model generates income distribution for the household groups. Poverty line is also endogenised in the model through the change in the relative prices. Change in poverty line and income distribution simultaneously affects the change in poverty incidence among household groups.

2. The Model

The model, which is based on the 1983 table updated to 1994–95 input–output (I–O) table, contains 23 production activities and three factors of production, viz., labour, land and non-land capital. Household, private corporate sector, public sector and government are other institutions. The household institution is classified into four rural categories and five urban categories (see Appendix A). As the model is a static one, investment acts as one of the final demands only. Exported and imported goods are differentiated from the domestically produced goods by constant elasticity of transformation (CET) and constant elasticity of substitution (CES) functions respectively. Neo-classical macro closure is assumed in the case of trade and investment-saving balance. Various policy simulations in regard to taxes and government expenditures have been attempted.

The authors are with NCAER.

The main aim of the model is to capture the impact of various macro-economic policy changes at the macro level on the poverty and welfare of the households. The model follows closely the applications of SAM-based CGE models to the developing countries. It is neo-classical and Walrasian in spirit. Some of the key features of the model are outlined below:

1. It is a static model where investment does not add to capital formation and is only one of the macro demand variables.

2. Physical non-land capital and labour are fully utilised and are mobile across sectors. Cropping land is also fully utilised and is mobile within the agricultural sector.

3. In the government budget constraint, transfer to households is constant and government real expenditure is fixed. The government saving is residually determined in the government budget.

4. In the external closure, the exchange rate moves freely in the system, while the foreign saving is fixed exogenously.

5. The model does not distinguish between purely exportable and importable sectors.

6. Foreign and domestically produced goods are assumed to be imperfect substitutes in use.

7. Imports of crude oil and natural gas, and petroleum products are canalised, i.e. the amount of import is not determined by the market, rather is determined by policy.

8. Investment in the economy is saving-driven.

9. Demands equal supplies in all commodities, and zero profits are made in all industries.

2.1 Production Activities and the Factor Market

Each production sector produces a single and distinct commodity. The output in a sector is a Leontief function of intermediate inputs and real value added in that

sector. The value added is a CES function of the primary factors, viz., labour input and capital stock. This nesting is taken care of in the following manner.

The output of the agricultural sector is a CES function of labour and composite capital, i.e. combination of land and non-land capital. The cost of production also includes the cost of fixed intermediate use. Composite capital is a Cobb-Douglas function of land and non-land capital.

The output of the non-agricultural sector is a CES function of labour and non-land capital. Land is not used in the non-agricultural sector for production purpose. There is a fixed intermediate use for the production of the sector's output.

It is assumed that factors are mobile across sectors and the aggregate labour supply and capital stock are fixed in the system. Land is used in the agricultural sector only and moves within the sector, i.e. it can be freely used by any of the sub-sectors within the agricultural sector. The total factor supplies are allotted to the different sectors according to the demands generated from them. Factor endowment of land comes from households, the private corporate sector and government. Households, the corporate sector, the public sector, government and the rest of the world contribute to the non-land capital endowment. Only households contribute to the labour supply.

Each production sector is assumed to be one firm, maximising profit using factors and intermediate products. The producers get revenue by selling their products. They make payments to the government as excise duties, to factors as wages on labour, rentals on capital and land, and to other producers for the purchase of raw materials. Their receipts are equal to their payments. This is called the zero profit condition. Prices attached to the demand for intermediate inputs are the producer prices, not the composite prices, because as per the assumption the intermediate inputs are not imported.

The producer behaviour described above results in well-behaved supply functions for commodities, demand functions for intermediate consumption and revenue (on account of excise duty) for the government. Given the wage rate and rental, the factor incomes are also determined.

2.2 Institutional Income and Consumption Demand

Consumers derive their income by selling the factors they own. Their budget also includes the taxes they pay to and transfers they receive from the government. Their

income includes transfer from abroad as well. The households are assumed to save a fixed fraction of their disposable income. The rest of it is spent on the consumption of goods. The consumption functions of the households are estimated by the most suitable Stone and Greary linear expenditure system (LES) which is widely used in India. Private corporate and public sectors do not have any consumption expenditure. They receive income from the rental values of non-land capital. The private corporate sector gets additional income from rental value of land and government transfer payment including interest payment.

2.3 Exports and Imports

Imports and exports augment the total supply and demand respectively. Conversely, imports deplete the demand, while exports deplete the supply in the domestic market. There are five non-importing and four non-exporting sectors (Appendix A).

The model follows the standard small country assumption, under which India can import as much as it wants, given the world price level. It is a price taker and cannot affect the world prices. For import, world prices are given and on the export side, a downward sloping world demand curve is assumed. Imports and exports are functions of world prices relative to the domestic prices and exchange rate. The importable goods are not the same as the domestic goods. The Armington assumption is used for this purpose. Exported goods are assumed to be different from goods for domestic consumption. To capture this, it is assumed that the domestic supply of output is a CET function of the above two.

Imports of crude oil and gas, and petroleum products are treated for quota restriction, as almost 98 per cent of these imports are canalised through canalised agencies. It is to be mentioned that though there is crude oil and gas sector in the model, there is, in fact, no import of natural gas. Hence, import of crude oil and gas would imply import of crude oil only. Whenever domestic demand for crude oil exceeds crude oil domestic production, government decides to go for canalised import. However, it's seen that the price of crude oil in the domestic market is always subsidised. On the other hand, the world price of crude oil is also exogenously fixed, which is supposed to be higher. The import of crude oil is determined by the domestic demand given the lower Armington elasticity. The difference between the world price and the import price faced by the domestic market can be called subsidy (negative rent) to the purchaser (during oil price shock international price is higher than the domestic price). After an oil price shock, subsidy goes up. The subsidy as a negative rent is a

drain on government revenue. However, in the process of liberalisation, this subsidy is supposed to be gradually reduced. The simulation has been carried out relaxing the assumption that the import price of crude oil in the domestic market is fixed. In this case, the import price is endogenously determined so that the subsidy on oil would go off. The subsidy or the negative rent is fixed at zero.

It is to be noted that the domestic consumption of the domestic supply does not include changes in stock. The change in stock (CIS) is priced at the time of production, which includes excise duty. However, there is no other indirect tax on it. Hence, for CET demand for domestic supply does not include CIS. Total value of CIS contributes to the gross investment of the economy, which equals gross savings of the economy.

2.4 The Government Sector

There is a very simplistic assumption for the government's behaviour. The government does not take part in production. It gets its revenue from excise duty on production, sales tax on goods, import duties on imported goods and income tax on households. Its income also includes capital income from entrepreneurship, income from land, and current as well as factor income from abroad. Government always balances its budget. Its budget also includes fixed transfer payments to households and the private corporate sector, while its real current consumption expenditure is fixed exogenously. Its saving is residually determined in the budget.

2.5 Model Closure and Equilibrium Conditions

The model presented is a purely static one. The endogenous variables are simultaneously determined in the system. The Walras' law holds as all the economic agents, households, producers and government balance their budgets. The gross domestic product is the same, calculated whether from income or from product side.

Both the domestic supply and the demand are functions of relative product and factor prices. Exports and imports are also functions of relative domestic and world prices. The excess demand functions are equalised to zero. They are homogeneous of degree zero in prices. Exchange rate is chosen as a numeraire and is normalised to unity.

The macroeconomic equilibrium conditions for the balance of payments and the saving–investment balance close the model. The total savings comprise private savings, government savings, corporate savings, public sector surplus earnings and foreign

savings. The total nominal investment in the economy is adjusted to the gross savings to balance the saving–investment closure. The sectoral demand of real investment without CIS depends on the composite price of the sectoral output and savings in the economy. Hence, the total nominal investment in the economy is composed of aggregate nominal sectoral investment demand without CIS and aggregate nominal sectoral CIS.

The balance of payment constraint holds. The foreign savings in dollar terms are the difference between total imports and total imports valued at the world price with net transfer and factor payment from abroad. For the specification of macro closure, exchange rate is endogenously determined while the foreign savings in dollar terms are fixed.

3. Calibration and the Benchmark Equilibrium Data Set

A social accounting matrix (SAM) gives the benchmark equilibrium data set for the model. The SAM used for the present study has been constructed by Pradhan and Sahoo (1996) using 1989–90 I–O table. The SAM is reproduced in Appendix B.

Calibration involves a deterministic approach in specifying parameter values to be used in an applied general equilibrium model (Shoven and Whalley, 1992). In calibration if the model is solved using the base year data inputs, the result will be the input data itself. This requires finding values of "shift" and "share" parameters for production functions, the CES aggregation function for imports and the CET function of exports. Given benchmark data for all the variables and with estimated elasticity parameters, the shift and share parameters are calibrated.

In the LES demand functions, the values of marginal budget shares have been estimated with the help of micro household data taken from the MIMAP Household Survey, NCAER (1999). In the benchmark, the minimum consumption parameters are calibrated with the use of these budget shares and the "supernumerary income ratio"[1] for each household.

In the benchmark equilibrium, units are so chosen that all the prices including factor prices are set to one except for the composite price. Given this, the associated quantities are known from the given SAM. After fixing numeraire, as the model satisfies

1. The supernumerary income ratio measures the amount of available spending power that consumers have above the minimum consumption level. For details see Taylor, 1990.

Walras' law, one of the demand–supply equilibrium equations—for the "other services sector" (S23)—is dropped. The model has been solved with the generalised algebraic modelling system (GAMS) software.

4. Poverty Measure and Income Distribution

In order to measure poverty within each social group, an estimation of income distribution within the respective group is required. The distribution will be used to evaluate the group poverty incidence. However, this assumes that, given the variances within the group, the intra-group distribution changes proportionally with the change in mean income. For this study, distribution within group will be given by a three-parameter lognormal frequency distribution. The benchmark lognormal parameters will be estimated using the MIMAP Survey data.

The following equation represents the lognormal distribution:

$$f(y) = 1/(\sqrt{2\pi}\sigma(y - \tau)) \exp - \tfrac{1}{2} \{[\log (y - \tau) - \mu]/\sigma\}^2$$

where τ, μ, and σ are minimum level of income, mean income and standard deviation respectively.

To analyse poverty, it is essential to find out a suitable measure. In order to arrive at the aggregated poverty alleviation effects, special classes of Foster, Greer and Thorbecke (FGT) (1984) measure have been used.[2] This measure is suitable to deal with group-wise poverty as it satisfies the decomposability assumption—the poverty measure is additively decomposable with population share weights.

The FGT measure is defined by:

$$P_\alpha = (1/n)\Sigma[(Z - Y_i)/Z]^\alpha$$

where "Z" is the poverty line, "n" is the number of people in a particular household group (i.e. occupational class), $(Z - Y_i)$ is the income shortfall of the ith household belonging to a particular household group, and α is a measure of poverty aversion. In this paper, special cases of FGT measure have been considered where α takes values 0, 1 and 2. When $\alpha = 0$, P_0 becomes the "head-count ratio measure", when $\alpha = 1$, P_1 is the "poverty-gap measure", and when $\alpha = 2$, P_2 becomes "distributionally sensitive measure". The higher degree of "poverty aversion", i.e. $\alpha = 2$, indicates that the poorest person should get relatively more weightage in the poverty measure.

2. The FGT satisfies the monotonicity axiom for $\alpha > 0$, the transfer axiom for $\alpha > 1$, and transfer sensitivity axiom for $\alpha > 2$. Sen (1976) proposed the first two axioms and Kakwani (1980) the last one.

The poverty measure is now expressed in terms of lognormal distribution. The above-mentioned P_α measure is no longer based on the discrete information. It is expressed in continuous distribution.

$$P_\alpha = \int[(Z - Y)/Z]^\alpha \, I\,(\mu, \sigma, \tau)\, dy$$

where $I\,(\mu, \sigma, \tau)$ is the income distribution of the household group. After transformation of the right hand side of the equation, the "head-count ratio" becomes:

$$P_0 = I_0\,(\mu, \sigma, \tau) = G\,\{[\log\,(z - \tau) - \mu]/\sigma\}$$

G is the standard normal distribution. Likewise one can compute the transformed expression for P_1 and P_2.

Poverty line Z will be endogenised in the CGE model through changes in the relative composite prices. The change in mean income of household group will come from the CGE simulations.

5. Policy Issues

For a model to be successful, it is essential to do some relevant simulation exercises that take into account various shocks as well as policy issues of the economy.

Different policy adjustments and shocks have significant effects on socio-economic groups. Besides policy shocks, the Indian economy has been susceptible to various crucial external shocks which, very often, have affected the economy in many ways. International oil shock is one of these. These, no doubt, affect household income and consumption levels and, hence, welfare and poverty. Crude oil constitutes a major chunk of India's import. Share of POL (petroleum, oil and lubricants) imports has significantly gone up from around 15 per cent in 1998–99 to around 22 per cent in 1999–2000 (Table 1). The Government of India (2001) sees that this rise in POL imports is attributed partly to the shift in the composition of POL imports from petroleum products to crude oil and partly to the rise in international crude oil prices.

The Indian economy is very sensitive to the fluctuation in international crude oil price. The sensitiveness is highly dependent on the degree of substitutability between demand for domestically produced oil and that for imported oil. Household welfare has been estimated using Hicksian equivalent variation (EV) measure.

Simulations

International crude oil price is increased by 40 per cent.
SIM1: Assuming a very low Armington import elasticity of 0.10.
SIM2: Assuming a high Armington import elasticity of 2.50.

Simulation pertaining to a rise in the world import price of crude oil and gas has negative impact on imports in the economy because of the direct increase in the cost of import (Simulations 1 and 2). Apart from the import of crude oil, imports of sectors linked with it, viz., agriculture, textiles and petrochemicals, have also declined (Tables 3 and 4).

As there is no export of crude oil and gas in the economy, this sector is, directly or indirectly, in most demand in the economy. With a very low import elastic case (SIM1 in Table 3), the import of crude oil does not decline as much as in the case of higher elastic cases (SIM2 in Table 4). With a higher cost of imported crude oil, import declines and demand pressure on the domestic production increases leading to a rise in the domestic production of crude oil. The composite price in the domestic market, i.e. the weighted average price of imported oil and domestically produced oil, rises significantly. Because of high market prices and decline in the domestic availability of crude oil, the petroleum products sector, which is highly dependent on crude oil as intermediate input, suffers a major decline in its production, followed by the "electricity" sector. Domestic prices and, hence, the composite prices of these sectors rise sharply. It is worth noticing that imports of sectors having very high Armington elasticity, viz., "other agriculture", "textiles" and "traditional manufacturing products" are affected more than that of crude oil itself. But resources are reallocated towards the production in these sectors. In the case of higher Armington elasticity scenario (SIM2 in Table 4) of crude oil and gas, decline in imports has been greater with more domestic production. It can be mentioned here that the model assumes fixed CIS for all the sectors. Given this assumption, effective increase in production in this sector may not be much. However, production of "petroleum products" would suffer to a lesser degree. In these scenarios, higher substitution of imports of crude oil to its demand for domestic production leads to reallocation of resources towards it. Production declines in most of the sectors. There has been a rise in the domestic prices and also in the composite prices.

Relative income of household groups seems to have fallen drastically in the lower elasticity case. In the higher elasticity case, the relative income prices have not fallen as much except for the agricultural self-employed class. However, in the higher elasticity case (SIM2 in Table 2), there has been a greater decline in the overall welfare as compared to in the lower elasticity case (SIM1 in Table 2). In this case relative domestic prices have increased. But there has been a relative change in the pattern of welfare of household groups across the scenarios. Though welfare declines maximum for rural agricultural household group and urban salaried class, in the lowest elasticity case (SIM1) the latter has the maximum fall over the former, and in the highest

elasticity case (SIM2) it is just the opposite (Table 2). In the case of rural artisans, rural other households, urban non-agricultural self-employed and urban non-agricultural labour household groups, the decline in welfare becomes of lesser degree as higher Armington elasticity is assigned to the imports of crude oil and gas. On the other hand, the decline has been more for the rest of the household groups in the same scenario.

Poverty both in rural and urban areas has gone up. However, irrespective of the change in the elasticity of substitution between demand for import of crude oil and that for domestically produced oil, change in poverty due to simulations across the household groups remains unchanged. Rise in rural poverty is concentrated among non-agricultural labour and other household groups, while that for urban area is reflected in non-agricultural household group. It is worth noticing that though the decline in welfare has been more for the rural agricultural self-employed, there is no change in poverty for this group. It may be because of the more distorted income distribution among artisans.

6. Conclusion

In any economy, external shocks play a very crucial role in affecting the domestic prices, demand and production. They affect the welfare and poverty of households directly as well as indirectly. The issue of international oil price shock has been of great concern in recent years in India. This issue has been analysed using a CGE model by endogenising income distribution and poverty. A sensitivity analysis has been carried out to see the degree of effect of this shock on the household groups as the elasticity of demand for imports vis-à-vis that for domestically produced oil is made to change. Oil shock leads to a decline in household welfare. With the higher elasticity of substitution for crude oil, there is greater welfare loss for household groups. However, international oil price shock seems to have minimal effect on the household poverty irrespective of the change in the elasticity of substitution between demand for import of crude oil and domestically produced crude oil. Rise in rural poverty is concentrated among non-agricultural labour and other household groups, while that for urban area is reflected in non-agricultural household groups.

Table 1

Production and Import of Crude Oil

(Qty: million tonnes, Value: Rs. crore)

	1995–96		1996–97		1997–98		1998–99		1999–2000	
	Qty	Value	Qty	Value	Qty	Value	Qty	Value	Qty	Value
Imports										
Crude oil	27.34	11517	33.91	18538	34.49	15897	39.81	14876	45.00	
Other POL products	20.34	12578	20.27	15633	19.53	12432	18.78	9837	13.10	
Total POL	47.68	24095	54.17	34171	54.02	28329	58.59	26919 (15%)		45421 (22%)
Total imports		122678		138920		154176		178332 (100%)		204583
Production										
Crude oil	35.17		32.90		33.86		32.72		31.90	

Source: Ministry of Petroleum and Natural Gas, Government of India, 2001.

Table 2
Change in Equivalent Variation and Percentage Change in Income

	SIM1 Armington elasticity 0.10			SIM2 Armington elasticity 2.50		
	EV*	Income	Poverty	EV*	Income	Poverty
Rural			0.13			0.13
Ag. self-employed	-22.51	-1.90	0.00	-27.63	-0.10	0.00
Ag. labour	-8.63	-1.90	0.00	-8.90	0.02	0.00
Artisans	-10.66	-1.86	0.39	-10.23	0.11	0.39
Other households	-9.25	-1.87	0.31	-9.57	0.04	0.31
Urban			0.05			0.05
Ag. household	-0.64	-1.75	0.00	-0.73	0.15	0.00
Non-ag. self-employed	-9.03	-1.69	0.00	-7.41	0.36	0.00
Salaried	-24.92	-1.92	0.00	-22.55	0.12	0.00
Non-ag. labour	-2.47	-1.84	0.39	-2.00	0.22	0.39
Other households	-1.54	-1.48	0.00	-2.29	0.35	0.00
Total	-88.97			-91.3		

* Household welfare is measured with the help of Hicksian equivalent variation (EV).

Table 3
Percentage Change in Output, Demands and Prices

	Simulation 1					
	Output	Exports	Imports	Domestic prices (PD)	Producers' prices (PQ)	Composite prices (PC)
S1	-0.33	0.51	-2.86	-1.60	-1.59	-1.59
S2	-0.09	0.82	-4.75	-1.88	-1.87	-1.86
S3	19.17	0.00	-15.70	-1.53	-1.53	21.27
S4	-0.04	0.43	-1.12	-1.01	-0.98	-0.63
S5	-0.14	1.13	-2.48	-1.60	-1.51	-1.51
S6	0.31	2.38	-3.35	-1.45	-1.31	-1.41
S7	0.16	1.04	-2.83	-1.35	-1.26	-1.26
S8	-3.00	-6.32	-0.98	16.30	16.02	12.62
S9	-0.08	0.40	-1.95	-0.86	-0.82	-0.77
S10	-0.45	-0.72	1.04	1.60	1.60	1.37
S11	0.05	0.24	-0.73	-0.65	-0.62	-0.50
S12	0.07	0.08	-0.09	-0.08	-0.08	-0.07
S13	-0.06	0.69	-0.76	-0.58	-0.56	-0.47
S14	-0.35	0.06	-1.30	-0.78	-0.74	-0.75
S15	-0.40	0.66	-1.66	-1.06	-1.04	-0.92
S16	0.48	1.17	-2.13	-1.30	-1.20	-0.87
S17	-0.21	0.00	0.00	-1.25	-1.25	-1.25
S18	-1.04	0.00	0.00	0.20	0.20	0.20
S19	-0.29	0.20	-1.13	-0.78	-0.74	-0.76
S20	-0.14	0.70	-2.02	-1.79	-1.78	-1.77
521	-0.09			-1.78	-1.78	-1.78
S22	-0.06			-1.95	-1.95	-1.95
S23	-0.03	0.68	-1.63	-1.51	-1.49	-1.49

Table 4
Percentage Change in Output, Demands and Prices

	Simulation 2					
	Output	Exports	Imports	PD	PQ	PC
S1	-0.41	-0.36	0.08	0.32	0.32	0.32
S2	-0.40	-0.24	-0.20	0.08	0.09	0.08
S3	46.83	-1.05	-33.46	0.71	0.71	20.01
S4	-1.15	-0.67	-0.05	1.06	1.07	0.66
S5	-0.56	-1.71	0.10	0.49	0.48	0.46
S6	-1.01	-0.89	0.85	0.77	0.73	0.75
S7	-0.67	-6.09	0.98	0.77	0.74	0.71
S8	-2.76	-0.81	-0.80	15.83	15.55	12.26
S9	-0.50	-1.37	1.68	1.04	1.02	0.92
S10	-0.85	-0.86	2.00	3.10	3.09	2.63
S11	-0.75	-0.94	0.46	1.19	1.20	0.92
S12	-0.14	-1.85	4.96	2.16	1.70	2.06
S13	-0.62	-0.62	0.74	1.22	1.19	0.99
S14	-0.48	-0.89	0.75	1.08	1.07	1.05
S15	-0.38	-0.93	0.64	0.87	0.86	0.76
S16	-0.65		0.91	0.82	0.78	0.54
S17	0.01			0.71	0.71	0.71
S18	-1.42	-0.86		2.02	2.02	2.02
S19	-0.55	-0.43	0.84	1.31	1.29	1.29
S20	-0.40		0.13	0.51	0.51	0.50
S21	-0.19			0.55	0.55	0.55
S22	-0.13	-0.30		0.22	0.22	0.22
S23	-0.13		0.44	0.53	0.53	0.52

References

Adelman, I. and S. Robinson (1988), "Macroeconomic Adjustment and Income Distribution—Alternative Models Applied to Two Economies", *Journal of Development Economics,* 29: 23–44.

Adelman, I. and S. Robinson (1978), *Income Distribution Policy in Developing Countries: A Case Study of Korea*, Stanford, CA: Stanford University Press.

Armington, P. S. (1969), "A Theory of Demand for Products Distinguished by Place of Production", *International Monetary Fund Staff Papers,* 16: 159–76.

Cornia, G. A., R. Jolly and F. Stewart (1987), *Adjustment with a Human Face: Vol. 1—Protecting the Vulnerable and Promoting Growth* (ed.), Oxford: Clarendon Press for UNICEF.

Decaluwe, B., A. Patry, L. Savard and E. Thorbecke (1999), "Poverty Analysis within a General Equilibrium Framework", in the *Report of the Regional Workshop on Modeling Structural Adjustment and Income Distribution: CGE Framework*, Dhaka, Bangladesh: CIRDAP.

Dervis, K. J. de Melo and S. Robinson (1982), *General Equilibrium Models for Development Policy*, Cambridge: Cambridge University Press.

Devrajan, S., J. D. Lewis and S. Robinson (1991), "From Stylized to Applied Models: Building Multisector CGE Models for Policy Analysis", *Working Paper No. 616*, Berkeley: Department of Agriculture and Natural Resources, University of California.

Dixon, P. B., B. R. Parmenter, A. A. Powell and P. J. Wilcoxen (1992), *Notes and Problems in Applied General Equilibrium Economics*, Amsterdam: North-Holland.

Foster, J. E., J. Greer and E. Thorbecke (1984), "A Class of Decomposable Poverty Measures", *Econometrica,* 52(3): 761–66.

Government of India (2001), *Basic Statistics on Indian Petroleum and Natural Gas Statistics, 1999–2000*, New Delhi: Ministry of Petroleum and Natural Gas.

Kakwani, N. (1980), "On a Class of Poverty Measures", *Econometrica*, 48(2): 437–46.

NCAER (1999), *MIMAP-India Survey Report*, New Delhi: National Council of Applied Economic Research.

Pradhan, B. K. (1995), "Modelling for MIMAP: A Survey", presented at MIMAP-International Workshop held at New Delhi during 6–7 November.

Pradhan, B. K. and A. Sahoo (1999), "Adjustment and Household Welfare: A Multisectoral Analysis", *Discussion Paper Series No. 11*, New Delhi: National Council of Applied Economic Research.

Pradhan, B. K. and A. Sahoo (1996), "Social Accounting Matrix and its Multipliers for India", *Margin*, 28(2): 153–69.

Sen, A. K. (1976), "Poverty: An Ordinal Approach to Measurement", *Econometrica*, 44(2): 219–31.

Shan, D. E., P. A. Dorosh and S. D. Younger (1997), *Structural Adjustment Reconsidered: Economic Policy and Poverty in Africa*, Cambridge: Cambridge University Press.

Shoven, J. B. and Whalley (1992), "A General Equilibrium Calculation of the Effects of Differential Taxation of Income from Capital in the U.S.", *Journal of Public Economics*, 1: 281–322.

Shoven, J. B. and Whalley (1984), "Applied General Equilibrium Models of Taxation and International Trade: An Introduction and Survey", *Journal of Economic Literature*, 22: 1007–51.

Taylor, Lance (1990), *Socially Relevant Policy Analysis—Structuralist Computable General Equilibrium Models for the Developing World,* London: The MIT Press.

Appendix A

The Indian economy comprises 23 sectors: 4 primary sectors, 14 secondary sectors and 5 service sectors.

Primary Sectors

S1. Foodgrains
S2. Other agriculture
S3. Crude oil and natural gas (non-exportable)
S4. Other mining and quarrying: coal and lignite, iron ore and other minerals

Secondary Sectors

S5. Food products and beverages
S6. Textiles
S7. Other traditional manufacturing goods, viz., wood, paper and leather products (tradable)
S8. Petroleum products
S9. Finished petrochemicals
S10. Fertiliser
S11. Other chemicals
S12. Non-metallic products: cement and other non-metallic mineral products
S13. Basic metal industries including iron and steel
S14. Metallic products
S15. Capital goods
S16. Other miscellaneous manufacturing industries
S17. Construction (non-tradable)
S18. Electricity (non-tradable)

Service Sectors

S19. Infrastructure services: gas and water supply, trade, transport, hotels and restaurants
S20. Financial services: banking and insurance
S21. Education (non-tradable)
S22. Health (non-tradable)
S23. Other services: public administration and defence, other personal services

Households

A. Rural Households

1. RAGSLF: agricultural self-employed
2. RAGLAB: agricultural labour
3. RNAG: artisans
4. ROTH: other households

B. Urban Households

1. UAG: agricultural households
2. UNAGSLF: non-agricultural self-employed
3. USALARY: salaried class
4. UNAGLAB: non-agricultural labour, i.e. casual labour
5. UOTH: other households

Appendix B

Production Function

For each non-agricultural sector, output is a CES production function of labour and non-land capital.

$$Q_{ng}(s) = A(s)*[\alpha(s)*L^d(s)^{(\sigma(s)-1)/\sigma(s)} + (1-\alpha(s))*K^d(s)^{(\sigma(s)-1)/\sigma(s)}]^{\sigma(s)/(\sigma(s)-1)}$$

(s = 3, ..., 23 production sectors)

Factor demands from the cost minimising behaviour:

$$L^d(s) = A(s)^{-1}* Q_{ng}(s)*\{\alpha(s) + (1-\alpha(s))*[\alpha(s)P_L/(1-\alpha(s))P_{nK}]^{(1-\sigma(s))}\}^{\sigma(s)/(1-\sigma(s))}$$

(s = 3, ..., 23)

$$K^d(s) = A(s)^{-1}* Q_{ng}(s)*\{\alpha(s) + (1-\alpha(s))*[\alpha(s)P_{nK}/(1-\alpha(s))P_L]^{(1-\sigma(s))}\}^{\sigma(s)/(1-\sigma(s))}$$

(s = 3, ..., 23)

Agricultural output is a function of labour and composite capital (land and non-land):

$$Q_{ag}(s) = A_g(s)*[\alpha1(s)*L^d(s)^{(\sigma(s)-1)/\sigma(s)} + (1-\alpha1(s))*K^d_{ag}(s)^{(\sigma(s)-1)/\sigma(s)}]^{\sigma(s)/(\sigma(s)-1)}$$

$$L^d(s) = A(s)^{-1}* Q_{ag}(s)*\{\alpha1(s) + (1-\alpha1(s))*[\alpha1(s)P_L/(1-\alpha1(s))P_K]^{(1-\sigma(s))}\}^{\sigma(s)/(1-\sigma(s))}$$

(s = S1, S2)

$$K^d_{ag}(s) = A(s)^{-1}* Q_{ag}(s)*\{\alpha1(s) + (1-\alpha1(s))*[\alpha1(s)P_K/(1-\alpha1(s))P_L]^{(1-\sigma(s))}\}^{\sigma(s)/(1-\sigma(s))}$$

(s = S1, S2)

The composite capital is a Cobb-Douglas aggregation of land and non-land capital.

$$K^d_{ag}(s) = K_{0ag}(s)*LD(s)^{\alpha1} K^d(s)^{(1-\alpha1)}$$

(s = S1, S2)

Zero Profit Condition for Output

Zero profit condition for composite capital in the agricultural sector can be written as:

$$P_K* K^d_{ag}(s) = P_{ld}*LD(s) + P_{nk}*K^d(s)$$

Value added and intermediate demands are fixed proportions of output. Then, the zero profit condition for each production is:

$$P_q(s)*(1-prtax(s))*Q_S(s) = P_L*L^d(s) + *K^d(s) + P_{ld}*LD(s) + \Sigma_t IOIN(t,s)*P_c(s)*Q_S(s).$$

Factor Market Equilibrium

Total factor endowment of household is equal to the total factor demand:

$$\Sigma_s L^d(s) = \Sigma_h L^S(h)$$

$$\Sigma_s K^d(s) = \Sigma_h K^S(h) + K_G + K_p + K_{pb} + K_r$$

$$(h = 1, \ldots, 7 \text{ households}; \; s = S1, \ldots, S23)$$

$$\Sigma_s LD^d(s) = \Sigma_h LD^s(h) + LD_g + LD_p$$

Disposable Income of Households

$$Y(h) = [P_L{*}L^S(h) + P_k{*}K^S(h)]{*}(1 - \text{inctax}(h)) + P_{ld}{*}LD_s(h) + TRNG(h) + TRNFRD(h){*}EXRAT$$

Disposable Income of Private Corporate Sector

$$PVY = (P_{nk}{*}K_p + P_{ld}{*}LD_p){*}(1 - \text{corptax}) + PVTRNG$$

Private corporate income is saved,

$$PVY = PVSAV$$

Public Sector Income

$$PBY = P_{nk}{*}K_{pb}$$

All its income is saved,

$$PBY = PBSAV$$

Household Consumption Demand

The household consumption demand for the composite goods is derived by maximising the Stone-Geary utility function such that

$$\Sigma_s Pc(s){*}\Sigma_s Cd(h, s) + PS(h) = Y(h)$$

Hence, the LES consumption demand function for composite goods becomes,

$$Cd(h,s) = C_0(h,s) + (\beta(h, s)/P_c(s)){*}[TotCd(h) - \Sigma C_0(h, s){*}P_c(s)]$$

where, $TotCd(h) = Y(h) - PS(h)$.

Household Savings

Private saving is a constant proportion of nominal disposable income,

$$PS(h) = S_0(h){*}Y(h)$$

Investment Demand

Sectoral investment demand by origin is a fixed proportion of the total investment in the economy.

$$Id(s) = i(s)*TINV/Pc(s)$$

The gross total investment including CIS is:

$$TINVEST = TINV + \Sigma_s CIS(s)*P_q(s)$$

Total Final Demand

$$FD(s) = \Sigma_h Cd(h,s) + Gd(s) + Id(s) + \Sigma_t IOIN(s,t)*Q(t)$$

$$Gd(s) = \text{sectoral government consumption expenditure}$$

Export Transformation

Price of export is defined as:

$$Px(s) = PWE(s)*EXRAT$$

And the exports face a constant elasticity demand function:

$$EXPT(s) = EXPT_0(s)*(PWE_0(s)/PWE(s))^{e(s)}$$

The CET function between domestically consumed goods and exported goods is given as:

$$Q_d(s) = CET(s)*[\pi(s)*EXPT(s)^{\omega(s)} + (1-\pi(s))*FDD(s)^{\omega(s)})^{(1/\omega(s))}$$

$Q_d(s)$ is the demand for sectoral output without inclusion of CIS. CET(s), $\pi(s)$ are technological constant and share parameters, and $\omega(s)$ is elasticity of transformation. FDD(s) is the final domestic demand for domestically produced goods.

Maximising the revenue from a given output:

$$Pq(s)*Q_d(s) = Pd(s)*FDD(s) + Px(s)*EXPT(s)$$

subject to CET function gives the ratio of exports to domestic sales:

$$EXPT(s)/FDD(s) = (\pi(s))/(1-\pi(s)))^{(1/(1-\omega(s)))}*(Px(s)/Pd(s))^{(1/(1-\omega(s)))}$$

Import Aggregation

Assuming that consumers try to minimise the cost of acquiring a given amount of the composite good, the desired ratio of imports to domestic commodity is derived from the first-order conditions of CES aggregation and is a function of the relative prices of the domestic good and imported substitute.

The CES aggregation function is:

$$FD(s) = ARM(s)*[\varphi(s)*IMP(s)^{-\rho(s)} + (1 - \varphi(s))*FDD(s)^{-\rho(s)})^{(-1/\rho(s))}$$

Minimising the cost of obtaining the unit composite good:

$$FD(s)*P_c(s) = FDD(s)*Pd(s)*(1 + saltax(s)) + IMP(s)*Pm(s)*(1 + tm(s))$$

subject to the CES function gives:

$$IMP(s)/FDD(s) = (\varphi(s)/(1 - \varphi(s)))^{(1/(1+\rho(s)))} *(Pq(s)*(1 + saltax(s))/Pm(s) *(1 + tm(s)))^{(1/(1+\rho(s)))}$$

FD(s) and IMP(s) are total final composite goods and imports. $\sigma(s)$, ARM(s) and $\rho(s)$ are share parameter, scale parameter and elasticity of substitution respectively. $P_c(s)$, slstax(s) and tm(s) represent composite price, sales tax rate and import tariff respectively.

World price is converted to import price by:

$$Pm(s) = PWM(s)*EXRAT$$

Commodity Market Equilibrium

$$Q_d(s) = Q_S(s) - CIS(s)$$

Equation for Change in Stock

$$CIS(s) = CIS0(s)* Q_S(s) \quad \text{(if CIS(s) is nonnegative)}$$

CIS(s) is exogenously fixed if CIS(s) is negative.

Saving-Investment Equilibrium

$$TS = TINVEST$$

Government Budget

Tax revenue:

$$TAXREV = \Sigma[P_L*L^S(h) + P_K*K^S(h)]*inctax(h) + (P_{nk}*K_p + P_{ld}*LD_p)*CORPTAX$$
$$\Sigma_s FD(s)*Pc(s)*saltax(s) + \Sigma_s Q_S(s)*Pq(s)*prtax(s) + \Sigma_s IMP(s)*PWM(s)*EXRAT*tm(s)$$

Total revenue:

$$REV = TAXREV + TRNFGRD*EXRAT + P_{nK}*K_G + P_{ld}* LD_g$$

Fiscal Balance

$$GS = REV - TRNGT - PVTRNG + Gd(s)*Pc(s)$$

$$TRNG(h) = TRN0(h)*TRNGT$$

Trade Balance

$$\Sigma_S(EXPT(s)*PWE(s)) - \Sigma_S(IMP(s)*PWM(s)) - P_{nk}* Kr + FSD + \Sigma_h TRNFRD(h) + TRNFGRD = 0$$

Total Savings

$$TS = \Sigma_h PS(h) + GS + PVSAV + PBSAV + FSD*EXRAT$$

Parameters and Exogenous Variables

1.	$\sigma(s)$	elasticity of substitution
2.	$\alpha(s)$	share parameters in the production
3.	$\alpha 1(s)$	share parameters in the Cobb-Douglas (CD) production function of agriculture
4.	$A_n(s)$	scale parameters in the production
5.	$A_g(s)$	scale parameters in agricultural production
6.	$K_{0ag}(s)$	scale parameter of CD function for composite capital in agriculture
7.	IOIN(t,s)	intermediate goods coefficients
8.	$V_0(s)$	proportion of value added to the output
9.	$C_0(s)$	minimum consumption of good "s" of household "h"
10.	$\beta(h,s)$	marginal budget share of household "h" for good "s"
11.	$S_0(h)$	constant proportion of household saving to disposable income
12.	i(s)	sectoral investment share by origin
13.	$\varphi(s)$	share parameters in the import CES aggregation function
14.	$\rho(s)$	elasticity of substitution between imported and domestically produced goods
15.	ARM(s)	scale parameters of the import (CES) aggregation function
16.	CET(s)	scale parameters of the export transformation function
17.	$\pi(s)$	share parameters in the export CET function
18.	$\omega(s)$	export elasticity of transformation
19.	e(s)	price elasticities of export demand
20.	Gd(s)	sectoral government "composite consumption"
21.	prtax(s)	net excise tax rates
22.	saltax(s)	sales tax rates
23.	inctax(h)	income tax rates
24.	corptax	corporate tax
25.	tm(s)	import tariff rates
26.	TRNFRD(h)	net transfer from the rest of the world to household in dollar terms
27.	PVTRNG	net government transfer to the private corporate sector
28.	TRNGT	total government transfer to the households
29.	TRN0(h)	household share of government transfer in total
30.	TRNFGRD	net transfer from the rest of the world to government in dollar terms

31. $L^s(h)$ household labour endowment
32. $LD^s(h)$ household land endowment
33. LD_g land endowment of government
34. LD_p land endowment of the private corporate sector
35. $K^S(h)$ non-land capital endowment of households
36. K_G non-land capital endowment of the government
37. K_p non-land capital endowment of the private corporate sector
38. K_{pb} non-land capital endowment of the public sector
39. K_r non-land capital endowment of rest of the world
40. $PWE_0(s)$ world export price
41. PWM(s) world import price
42. $EXPT_0(s)$ constant term in the export demand function
43. FSD foreign savings in dollar terms
44. CIS0(s) sectoral change in stock as share of production
45. CIS(s) exogenously fixed real CIS (for negative CIS)
46. S_0 constant proportion of household savings to the household disposable income

Endogenous Variables

1. $P_c(s)$ prices of composite goods for domestic demand
2. P_L unit price of labour
3. P_K unit price of composite capital for agriculture
4. P_{nk} unit price of non-land capital
5. P_{ld} unit price of land
6. Pq(s) producer's prices
7. Pd(s) domestic price of domestically produced goods
8. Pm(s) domestic prices of imported goods
9. PWE(s) India's export price faced by the trading country
10. Px(s) export price in dollar
11. $Q_S(s)$ sectoral output
12. $Q_{ag}(s)$ output of agriculture
13. $Q_{ng}(s)$ output of non-agricultural sector
14. $L^d(s)$ sectoral labour demand
15. $K^d(s)$ sectoral non-land capital demand
16. $K_{0ag}(s)$ scale parameter in land and non-land capital aggregation
17. $K^d_{ag}(s)$ factor demand for composite capital for agriculture

18.	$LD^d(s)$	factor demand of land for agriculture
19.	Cd(h,s)	household sectoral consumption demand for composite goods
20.	PS(h)	household savings
21.	Id(s)	composite investment demand
22.	$Q_d(s)$	total demand for output without change in stock (CIS)
23.	Y(h)	disposable income of the household
24.	PVY	disposable private sector income
25.	PBY	public sector income
26.	TAXREV	tax revenue
27.	REV	total government revenue
28.	FDD(s)	final domestic demand for domestically produced goods
29.	FD(s)	total final demand
30.	EXRAT	exchange rate
31.	TS	total savings in the economy
32.	PVSAV	private sector savings
33.	PBSAV	public sector surplus earnings
34.	GS	government savings
35.	TRNG(h)	government transfer to the household "h"
36.	TINV	total investment without CIS in the economy
37.	TINVEST	gross investment with CIS
38.	CIS(s)	real change in stock (for positive CIS)
39.	TotCd(h)	total nominal consumption expenditure of household "h"
40.	IMP(s)	volume of imports
41.	EXPT(s)	volume of exports