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THE INDIA MODEL
OF
PRODUCTION, TRADE AND EMPLOYMENT

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and

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Foreword

The basic objective of this study is to evaluate the comparative static effects of selected trade and domestic policy reforms on trade, output, domestic prices, economic welfare and intersectoral allocation of resources. The major reforms analysed in this study relate to reduction in tariff and non-tariff barriers to trade along with rationalisation of the tax-regime. A Computable General Equilibrium (CGE) Model of the Indian Economy has been constructed for the purpose of analysis.

The present Working Paper documents the India CGE Model of production, trade and employment and is capable of evaluating the comparative static effects of selected trade and domestic policy reforms on output, trade, factor prices, economic welfare and intersectoral allocation of resources. It is a single country (versus rest-of-world) multi-sectoral model. The major source of inspiration has been the multi-country structure used in the Michigan Brown-Deardorff-Stern (BDS) CGE Model of World Production and Trade.

We acknowledge with gratitude the critical comments and suggestions provided to us by the members of the Advisory Committee for this Project. Prof. Thomas W. Hertel of the Purdue University, USA and Professors K.L. Krishna and V. Pandit of the Delhi School of Economics, India have played very special role in this regard.

The analysis of the India CGE Model developed in the present study has been made possible through the use of General Equilibrium Modelling Package (GEMPACK) Software developed at Monash University, Melbourne, Australia by

Professors Jill Harrison and Ken Pearson. We are extremely thankful to Prof. Ken Pearson for his prompt and active support in making this software package operative on NCAER's UNIX computer.

Prof. S.L. Rao, former Director General, NCAER was instrumental in getting this study started and took keen interest in its progress.

The current study is an outcome of a research project which has been funded by the USAID, New Delhi. We are thankful to them for their financial support. Mr. Jon O'Rourke and Dr. Madhumita Gupta, both from USAID, deserve our special thanks.

Rakesh Mohan
Director-General

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THE INDIA MODEL
OF
PRODUCTION, TRADE AND EMPLOYMENT

IN THIS PAPER, we outline the India computable general equilibrium (CGE) model that we have developed to evaluate the comparative static effects of selected trade and domestic policy reforms on output, trade, factor prices, economic welfare and intersectoral allocation of resources. The India CGE model is a single country (versus rest-of-world) multi-sectoral computable general equilibrium model. Though this is a single country model, the major source of inspiration has been the multi-country structure used in the Michigan Brown-Deardorff-Stern (BDS) CGE Trade Model (1995) and various research papers by the same authors.

1. Policy Relevance

The unilateral trade and industry policy reforms since July 1991 should be viewed in the context of the unilateral measures undertaken by many other developing countries in the past few years. Moreover, major trading partners of India in the Asian region as well as elsewhere have witnessed changes in recent years with regard to the rise of regionalism within a broader GATT/WTO framework. The USAID funded research programme undertaken by NCAER, in collaboration with the University of Michigan, has enabled NCAER to develop a stand alone computable general equilibrium (CGE) model for India

to analyse the impact of unilateral reform measures on India's economy.

Such policy changes are likely to have medium to longer term impact on micro or industry level variables within the domestic economies of the concerned countries along with re-alignment of production across countries of the world. There is an ongoing debate on the likely impact of such reforms on the economy's output, employment and other variables signifying changes in the economic conditions of the country's population. It thus becomes important to evaluate the effects of such policy reforms on factor prices, output, and trade, along with inter-sectoral movement of resources, *viz.* land, labour and capital. The effects will also show up in international re-allocation of production. The research evaluations should help to provide an assessment of the impact so that the policy debate can be based on empirical findings rather than mere theoretical conjectures.

This provides an empirical basis for discussions on the impact of policy changes, especially the policies relating to trade. The issues which we intend to analyze have immense policy relevance for India. For example, the policy makers need to know the likely direction of inter-sectoral changes that would result when India undertakes unilateral trade and industry policy reforms. The industrial structure is expected to become aligned to the one that is internationally competitive. Thus, there would be re-allocation of resources across sectors as a result of unilateral changes in trade policy.

The analysis also indicates relative strengths of the sectors in making decisions with regard to future investments. The implications for expanding and contracting sectors in terms of employment policies are also clearly brought out by the analysis.

The analysis provides estimates of likely changes in the composition and the direction of India's trade, in the medium to longer term, vis-a-vis different sectors of the economy. Finally, we also address the issue of changes in overall welfare of the economy. This provides us with an indication of changes in benefits to the economy as a whole.

The study, therefore, provides an important basis for discussions on policy reforms which aim at freer trade and a more liberalized market regime for the economy. Such analysis can be facilitated through the use of the Computable General Equilibrium (CGE) approach. The single country version of the Michigan Model is capable of analyzing such effects on a country which chooses to undertake unilateral liberalization. A single country version of the Michigan Model for the Indian economy has been developed by NCAER in association with the University of Michigan.

2. CGE Models : Conceptual Issues and Brief Survey

The "computable general equilibrium" (CGE) modelling approach is an empirical counterpart of the well-known general equilibrium analysis. The term "general equilibrium" refers to an analytical approach which views the economy as a complete system of inter-dependent components, such as industries, households, investors, government, importers and exporters (Dixon *et al.*, 1992). The term "applied" refers to the importance of this technique in providing quantitative analysis of the economic policy problems in a country or in a group of countries.

Whereas a partial equilibrium approach may be preferred due to its analytical simplicity, reliability of the results increases

considerably by using a general equilibrium approach (Whalley, 1975). Hence, in the CGE approach, the emphasis is put on numerical solution rather than obtaining formal analytical proofs of the existence and the uniqueness of equilibrium as in formal theoretical general equilibrium analysis (Bandara, 1991). In the CGE framework, the main focus of the analysis is quantitative and is based on empirical data from the particular country or group of countries being investigated. This enables one to obtain more useful information for analyzing the policy variables than is possible with theoretical general equilibrium analysis. Thus, CGE models are convenient tools for investigating the potential impacts of various economic policy changes on microeconomic and structural variables in an economy[1].

Many CGE model exercises have been devoted to the impact of changes in policies related to international trade by a country or a group of countries. For example, it is possible to compute the potential effects of a proposed cut in tariffs by an economy (group of economies) on aggregate employment, the balance of trade, employment and output across different sectors in the concerned economy (group of economies). There will be a change in the consumption pattern of the tariff reducing country due to changes in the relative prices of imports and domestic goods. This will induce changes in allocation of resources in the country. Such a chain of events can not be captured by partial equilibrium models and CGE models are therefore more suitable for the purpose.

As mentioned earlier, many CGE modellling exercises have been devoted to the impact of changes in policies related to

[1] For a detailed discussion on the use of CGE models for development policy analysis in less developed countries (LDCs), refer to Bandara (1991).

international trade by a country or a group of countries. Most of these applications have been on protection, including tariff and non-tariff barriers. Beside these issues, the CGE models have been used for analysing issues relating to exchange rate policy, alternative trade strategy, export subsidies or taxes and foreign capital inflows. Some of the developing countries investigated by these studies are Chile (by Taylor and Black, 1974), Ivory Coast (by Staelin, 1976), Colombia (by de Melo, 1978), and Turkey (by Dervis, 1980, 1982, and by Grais *et al.*, 1986).

The income distribution aspects of any development policy have always been a topic of major concern in the developing countries. So, it is hardly surprising to find a number of CGE studies addressing issues relating to the distributional implications of different development strategies and designing policy packages in order to reduce poverty and income inequality associated with industrialization. The first attempt in this direction was the study by Alderman and Robinson (1978) for Korea. This was followed by models of Brazil by Taylor *et al.* (1980), Malaysia by Ahluwalia & Lysy (1981), and Turkey, Kenya and India by Gupta & Togan (1984).

The government tax/subsidy and expenditure policy issues have also been investigated using CGE framework. The foremost study for developing country in this area is the study by Serra-Puche (1984) which analyses the tax reform in 1980 in Mexico. In many LDCs, policies of food subsidies play a major role in political economy. There have been a number of studies concerned with this issue, for example McCarthy & Taylor (1980) for Pakistan, McCarthy (1981, 1983) for Brazil and Egypt, and Eckaus & Mohie-Eldin (1980) for Egypt.

3. The Existing Models of the Indian Economy

Economy-level empirical models have frequently been used for forecasting and policy analysis. Most of the existing models of the Indian economy are of the econometric and planning variety. These have been used primarily for policy analysis and forecasting. Marwah (1991) notes that about 80 models of different types have been developed for the Indian economy during the preceding four decades. These include nearly 40 econometric macro models (Krishnamurty, 1992). There have been very few attempts to develop CGE models of the Indian economy (Bandara, 1991). Mohan (1977) developed a non-linear three-sector (agriculture, industry and services), two-region (rural and urban) model of the Indian economy to analyse the process of economic growth. With the improved availability of the database and the advanced computing facilities over the years, the models developed since the late 1970s are relatively more detailed and complex compared to the earlier ones.

Bandara (1991) reports on six CGE models developed for the Indian economy. Gupta and Togan (1984) developed a 4-sector model based on input-output (I-O) tables to analyze the effects of four alternative economic policies on income distribution. Cole and Meagher (1984) developed a 3-sector social accounting matrix (SAM) based macro model for analyzing the effects of various redistribution policies considering a two-way relation between growth and income distribution. Narayana *et al.* (1987) constructed a 10-sector model to analyze the effects of *(a)* policies of foodgrains purchasing and subsidized distribution to the consumers and *(b)* foreign trade and aid policies on growth and income distribution. Rattso (1987, 1988) developed a 5-sector SAM based model to analyse the effects of changes in fiscal policy and the investment strategy of the government as well as of

the private sector on growth and inflation. The model developed by Gupta (1983) had the highest disaggregation (12-sectors) and was based on I-O tables. It analyses the re-allocative effects of a sharp increase in oil prices in the short-run and the medium-run. The short-run results show that the composition of industrial structure moves away from traded to non-traded goods combined with a reduction in GDP. The GDP recovers in the medium-term but not to the earlier level.

The economy level modelling activity at NCAER has been going on since the early 1980s. Currently, there are two types of macro model operative at NCAER. The first to be developed is a structuralist CGE macro model (Bhide and Pohit, 1993) of the Indian economy. It is a SAM-based model which provides conditional short-term forecasts and is capable of analysing various macro policy scenarios and providing assessment of the economy under alternative assumptions. The second macro model operative at NCAER is an econometric model for India (Joshi *et al.*, 1995). It is capable of providing a medium-term assessment of the economy. The disaggregated structure of the model with some dynamic elements (through lags and capital stock updating) built into it allows for detailed forecasts.

4. The Distinguishing Features of the India CGE Model

The CGE model that has been developed in the present study is distinctly different from the existing models of the Indian economy. It is a single country (versus rest-of-world) model and is capable of evaluating the comparative static effects of selected trade and domestic policy reforms on output, trade, factor prices, economic welfare and intersectoral allocation of resources across 34 sectors of the economy. It also permits analysis of the economy-wide impacts. The major source of

inspiration in developing this model has been the multi-country structure used in the Michigan Brown-Deardorff-Stern (BDS) CGE Model (Brown *et al.*, 1995) and various other research papers by the same authors (*see* References).

The India CGE Model has various departures from the assumptions of the Heckscher-Ohlin (H-O) Model of international trade. This model incorporates several of the assumptions of the New Trade Theory such as particular forms of increasing returns to scale, product differentiation and imperfect competition, none of which is permitted in the H-O Model (*see* Brown *et al.*, May 1993).

The agricultural and service sectors in India are characterized as being perfectly competitive though paddy and wheat sectors are under administered price regime while the rail transport sector is a state monopoly sector. The product of each of these sectors is assumed to be homogeneous but differentiated from imports. The assumption of national product differentiation for agriculture and service sectors implies that the so-called Armington assumption is being applied and that India will have some degree of monopoly power in trade in this sector.

The manufacturing sectors are characterized as being monopolistically competitive with free entry, and the products that are produced and traded are assumed to be differentiated by firm (Helpman and Krugman, 1985). Product differentiation by firm dispenses with the Armington assumption, so that the potentially strong terms-of-trade effects associated with national monopoly power are greatly diminished. Varieties enter via a Dixit-Stiglitz (1977) aggregation function into both utility and production functions, with implications that greater variety reduces cost and increases utility. However, some of the manufacturing sectors in India are state monopolies. The prices

in these sectors are administered and products may be considered to be homogeneous only to be differentiated from imports. The same holds true of three private sectors in which the prices are administered. These are paper products, fertilizer and non-ferrous metals.

It is thus assumed that there are constant returns to scale in the agricultural sectors and increasing returns to scale in the manufacturing sectors.

5. Model Implementation

The reference year of the model is 1989-90. The trade policy inputs into the model are the tariff and non-tariff barriers (NTBs) that were applicable to India's trade in 1989-90. In order to investigate sectoral employment effects of the unilateral trade liberalization, it has been assumed that the existing bilateral tariffs will be removed and NTBs will be relaxed in two stages, the first stage to be completed by the mid-1990s and the second towards the end of 1990s.

The domestic policy inputs include reduction in 'other net indirect taxes' (indirect taxes net of custom duty and subsidies) and changes in administered prices in the regulated sectors. Since July 1991, there has been an effort to reduce indirect taxes and to increase the administered prices of paddy and wheat.

When policy changes are introduced into the model, the method of solution yields percentage changes in sectoral employment and certain other variables of interest for India. Multiplying the percentage changes by actual (1989-90) levels given in the database yields the absolute changes, positive or negative, that might result of one-time unilateral trade and domestic policy reforms in India.

In addition to the sectoral effects which are the primary focus of our analysis, the model also yields results for changes in total exports, total imports, the terms of trade, the overall level of welfare in the economy, and the economy-wide changes in real wages and returns to capital. Because both labour and capital are assumed to be homogeneous and intersectorally mobile in these scenarios[2], we cannot distinguish effects on factor prices by sector. Nor can we distinguish effects on different skill groups or other categories of labour. In particular we are unable to address the important question of how trade liberalization might affect the differential between the wages of skilled and unskilled workers.

In this model, we do not distinguish consumption from other forms of final demand. It is also assumed that aggregate expenditure varies endogenously to hold the aggregate employment constant. Such a closure may be thought of as analogous to the Johansen closure rule (Deardorff and Stern, 1990). The Johansen closure rule consists of keeping the requirement of full employment while dropping the consumption function. This means that consumption can be thought of adjusting endogenously to ensure full employment. However, in the present model, we do not distinguish consumption from other forms of final demand. In fact, we assume that expenditure adjusts to maintain full employment which may be thought of as analogous to the Johansen closure rule.

6. Documentation of the India CGE Model

The India CGE Model is a single country multi-sectoral computable general equilibrium model. Though this is a single country model, the major source of inspiration has been the multi-country structure used in the Michigan Brown-Deardorff-

[2] The capital stock is assumed to remain fixed in the state monopoly sectors.

Stern (BDS) Computable General Equilibrium Trade Model (1995) and various earlier research papers by the same authors (see references). India is modelled to produce, consume and trade 33 tradable goods. In addition, there is one non-traded sector, *i.e.* rail transport. The sectoral breakdown, as shown in *Table 1*, has been concorded from ISIC Rev. 2. *Table 2* provides a key to the sectoral classification into different sets and subsets. *Tables 3* is an extension of *Table 2* to facilitate a better understanding of the sectoral classification.

The market structure in 29 out of 34 sectors is either perfectly competitive or monopolistically competitive, depending on the degree of scale economies in production. The remaining 5 sectors are assumed to be state monopolies (SMS), including rail transport, which is the only non-traded sector. The other four state monopoly sectors are petroleum products, iron & steel, mining & quarrying, and electricity, gas and water supply. Out of 33 tradable sectors, 9 are assumed to be under perfect competition (TPCS) and 4 under state monopolies (TMCS). The remaining 20 sectors are assumed to be under monopolistic competition (TICS). These include three sectors in which prices are administered (TICSAP). Thus, 17 out of 20 sectors are really under monopolistic competition (TMCS).

The final consumer demand equations for various sectors are obtained assuming a representative consumer who maximizes utility subject to a budget constraint. The revenue from tariffs and indirect taxes along with profits of the state monopoly sectors are assumed to be redistributed to consumers and spent. Intermediate demands are derived from the profit maximizing decisions of the representative firms in each sector. Products in all the tradable sectors are assumed to be characterized by some degree of product differentiation. In nine of the sectors where markets are taken to be perfectly

Table 1

Sectoral Breakdown of India CGE Model

S.No.	Sector	ISIC Code
1.	Paddy	1A
2.	Wheat	1B
3.	Other cereals	1C
4.	Other agriculture	1D
5.	Food, beverages, tobacco	310
6.	Textiles	321
7.	Clothing	322
8.	Leather products	323
9.	Footwear	324
10.	Wood products	331
11.	Furniture and fixtures	332
12.	Paper and paper products	341
13.	Printing and publishing	342
14.	Fertilizer	35A
15.	Other chemicals	35B
16.	Petroleum and related products	35C
17.	Rubber products	355
18.	Non-metallic mineral products	36A
19.	Glass and glass products	362
20.	Iron and steel	371
21.	Non-ferrous metals	372
22.	Metal products	381
23.	Non-electric machinery	382
24.	Electric machinery	383
25.	Transport equipment	384
26.	Miscellaneous manufactures	38A
27.	Mining & quarrying	2
28.	Electricity, gas & water supply	4
29.	Construction	5
30.	Wholesale trade	6
31.	Rail transport	7A
32.	Other transport, storage and communication	7B
33.	Financial services	8
34.	Personal services	9

Note : ISIC codes are as per Rev. 2.

Table 2

Sectoral Sets Specification

ALS	=	TRS + NTS
TRS	=	TICS + TSMS + TPCS
TPCS	=	TAGS + TNAGS
TAGS	=	TAGSAP + TAGSNA
TICS	=	TMCS + TICSAP
NTS	=	NSMS
SMS	=	TSMS + NSMS
APS	=	TAGSAP + SMS + TICSAP
TAPS	=	APS - NSMS

where,

ALS	:	all sectors (1..34)
TRS	:	tradable sectors (1..34 except rail transport, i.e. 31)
NTS	:	non-traded sectors (31)
TPCS	:	tradable perfect competition sectors (1..4, 29..34 except 31)
TAGS	:	tradable agricultural sectors (1..4)
TNAGS	:	tradable non-agriculture perfect competition sectors (29..34 except 31)
TAGSAP	:	TAGS under administered price (1, 2)
TAGSNA	:	TAGS under free price (3, 4)
TSMS	:	tradable state monopoly sectors (16, 20, 27, 28)
TICS	:	tradable imperfect competition sectors (5..27 except TSMS)
TICSAP	:	TICS under administered price (12, 14, 21)
TMCS	:	TICS under monopolistic competition (TICS except TICSAP)
NSMS	:	non-traded state monopoly sectors (31)
SMS	:	state monopoly sectors (TSMS and NSMS)
APS	:	sectors under administered prices (TAGSAP, TSMS, TAPS, NSMS)

Table 3
Mapping of Sets

S. No.	India Model Sector	ISIC Code	Sets ALS	TRS	NTS	TPCS
1.	PADDY (PAD)	1A	√	√		√
2.	WHEAT (WHT)	1B	√	√		√
3.	OTHER CEREALS (OCR)	1C	√	√		√
4.	REST OF AGRICULTURE (ROA)	1D	√	√		√
5.	FOOD, BEV. & TOBACCO (FBT)	310	√	√		
6.	TEXTILES (TEX)	321	√	√		
7.	CLOTHING (CLO)	322	√	√		
8.	LEATHER PRODUCTS (LPR)	323	√	√		
9.	FOOTWEAR (FWR)	324	√	√		
10.	WOOD PRODUCTS (WPR)	331	√	√		
11.	FURNITURE FIXTURES (FRF)	332	√	√		
12.	PAPER PRODUCTS (PPR)	341	√	√		
13.	PRINTING & PUBLISHING (PRP)	342	√	√		
14.	FERTILIZER (FRT)	35A	√	√		
15.	OTHER CHEMICALS (OCH)	35B	√	√		
16.	PETROLEUM PRODUCTS (PET)	35C	√	√		
17.	RUBBER PRODUCTS (RPR)	355	√	√		
18.	NON-METALLIC MIN. PROD. (NMM)	36A	√	√		
19.	GLASS PRODUCTS (GPR)	362	√	√		
20.	IRON & STEEL (IRS)	371	√	√		
21.	NON-FERROUS METAL (NFM)	372	√	√		
22.	METAL PRODUCTS (MPR)	381	√	√		
23.	NON-ELEC. MACHINERY (NEM)	382	√	√		
24.	ELECTRICAL MACHINERY (ELM)	383	√	√		
25.	TRANSPORT EQUIPMENTS (TRE)	384	√	√		
26.	MISC. MANUFACTURING (MMF)	38A	√	√		
27.	MINING & QUARRYING (MNQ)	2	√	√		
28.	ELECTRICITY, GAS & WATER (EGW)	4	√	√		
29.	CONSTRUCTION (CON)	5	√	√		√
30.	WHOLESALE & RETAIL TRADE (WRT)	6	√	√		√
31.	RAIL TRANSPORT (RLT)	7A	√		√	
32.	OTHER TRANSPORT, STORAGE & COMMUNICATIONS (TSC)	7B	√	√		√
33.	FINANCE, INS. & REAL EST. (FIR)	8	√	√		√
34.	COMM., SOCIAL & PERS. SERV. (CSP)	9	√	√		√

(Continued)

***Table 3 :* Mapping of Sets** *(Continued)*

S. No.	India Model Sector	ISIC Code	Sets			
			TAGS	TNAGS	TAGSAP	TAGSNA
1.	PADDY (PAD)	1A	√		√	
2.	WHEAT (WHT)	1B	√		√	
3.	OTHER CEREALS (OCR)	1C	√			√
4.	REST OF AGRICULTURE (ROA)	1D	√			√
5.	FOOD, BEV. & TOBACCO (FBT)	310				
6.	TEXTILES (TEX)	321				
7.	CLOTHING (CLO)	322				
8.	LEATHER PRODUCTS (LPR)	323				
9.	FOOTWEAR (FWR)	324				
10.	WOOD PRODUCTS (WPR)	331				
11.	FURNITURE FIXTURES (FRF)	332				
12.	PAPER PRODUCTS (PPR)	341				
13.	PRINTING & PUBLISHING (PRP)	342				
14.	FERTILIZER (FRT)	35A				
15.	OTHER CHEMICALS (OCH)	35B				
16.	PETROLEUM PRODUCTS (PET)	35C				
17.	RUBBER PRODUCTS (RPR)	355				
18.	NON-METALLIC MIN. PROD. (NMM)	36A				
19.	GLASS PRODUCTS (GPR)	362				
20.	IRON & STEEL (IRS)	371				
21.	NON-FERROUS METAL (NFM)	372				
22.	METAL PRODUCTS (MPR)	381				
23.	NON-ELEC. MACHINERY (NEM)	382				
24.	ELECTRICAL MACHINERY (ELM)	383				
25.	TRANSPORT EQUIPMENTS (TRE)	384				
26.	MISC. MANUFACTURING (MMF)	38A				
27.	MINING & QUARRYING (MNQ)	2				
28.	ELECTRICITY, GAS & WATER (EGW)	4				
29.	CONSTRUCTION (CON)	5		√		
30.	WHOLESALE & RETAIL TRADE (WRT)	6		√		
31.	RAIL TRANSPORT (RLT)	7A				
32.	OTHER TRANSPORT, STORAGE & COMMUNICATIONS (TSC)	7B		√		
33.	FINANCE, INS. & REAL EST. (FIR)	8		√		
34.	COMM., SOCIAL & PERS. SERV. (CSP)	9		√		

(Continued)

Table 3 : Mapping of Sets (*Continued*)

S. No.	India Model Sector	ISIC Code	Sets TSMS	TICS	TICSAP	TMCS
1.	PADDY (PAD)	1A				
2.	WHEAT (WHT)	1B				
3.	OTHER CEREALS (OCR)	1C				
4.	REST OF AGRICULTURE (ROA)	1D				
5.	FOOD, BEV. & TOBACCO (FBT)	310		√		√
6.	TEXTILES (TEX)	321		√		√
7.	CLOTHING (CLO)	322		√		√
8.	LEATHER PRODUCTS (LPR)	323		√		√
9.	FOOTWEAR (FWR)	324		√		√
10.	WOOD PRODUCTS (WPR)	331		√		√
11.	FURNITURE FIXTURES (FRF)	332		√		√
12.	PAPER PRODUCTS (PPR)	341		√	√	
13.	PRINTING & PUBLISHING (PRP)	342		√		√
14.	FERTILIZER (FRT)	35A		√	√	
15.	OTHER CHEMICALS (OCH)	35B		√		√
16.	PETROLEUM PRODUCTS (PET)	35C	√			
17.	RUBBER PRODUCTS (RPR)	355		√		√
18.	NON-METALLIC MIN. PROD. (NMM)	36A		√		√
19.	GLASS PRODUCTS (GPR)	362		√		√
20.	IRON & STEEL (IRS)	371	√			
21.	NON-FERROUS METAL (NFM)	372		√	√	
22.	METAL PRODUCTS (MPR)	381		√		√
23.	NON-ELECTRICAL MACHINERY (NEM)	382		√		√
24.	ELECTRICAL MACHINERY (ELM)	383		√		√
25.	TRANSPORT EQUIPMENTS (TRE)	384		√		√
26.	MISC. MANUFACTURING (MMF)	38A		√		√
27.	MINING & QUARRYING (MNQ)	2	√			
28.	ELECTRICITY, GAS & WATER (EGW)	4	√			
29.	CONSTRUCTION (CON)	5				
30.	WHOLESALE & RETAIL TRADE (WRT)	6				
31.	RAIL TRANSPORT (RLT)	7A				
32.	OTHER TRANSPORT, STORAGE & COMMUNICATIONS (TSC)	7B				
33.	FINANCE, INS. & REAL EST. (FIR)	8				
34.	COMM., SOCIAL & PERS. SERV. (CSP)	9				

(Continued)

***Table 3 :* Mapping of Sets** (*Continued*)

S. No.	India Model Sector	ISIC Code	Sets NSMS	SMS	APS	TAPS
1.	PADDY (PAD)	1A			√	√
2.	WHEAT (WHT)	1B			√	√
3.	OTHER CEREALS (OCR)	1C				
4.	REST OF AGRICULTURE (ROA)	1D				
5.	FOOD, BEV. & TOBACCO (FBT)	310				
6.	TEXTILES (TEX)	321				
7.	CLOTHING (CLO)	322				
8.	LEATHER PRODUCTS (LPR)	323				
9.	FOOTWEAR (FWR)	324				
10.	WOOD PRODUCTS (WPR)	331				
11.	FURNITURE FIXTURES (FRF)	332				
12.	PAPER PRODUCTS (PPR)	341			√	√
13.	PRINTING & PUBLISHING (PRP)	342				
14.	FERTILIZER (FRT)	35A			√	√
15.	OTHER CHEMICALS (OCH)	35B				
16.	PETROLEUM PRODUCTS (PET)	35C		√	√	√
17.	RUBBER PRODUCTS (RPR)	355				
18.	NON-METALLIC MIN. PROD. (NMM)	36A				
19.	GLASS PRODUCTS (GPR)	362				
20.	IRON & STEEL (IRS)	371		√	√	√
21.	NON-FERROUS METAL (NFM)	372			√	√
22.	METAL PRODUCTS (MPR)	381				
23.	NON-ELECTRICAL MACHINERY (NEM)	382				
24.	ELECTRICAL MACHINERY (ELM)	383				
25.	TRANSPORT EQUIPMENTS (TRE)	384				
26.	MISC. MANUFACTURING (MMF)	38A				
27.	MINING & QUARRYING (MNQ)	2		√	√	√
28.	ELECTRICITY, GAS & WATER (EGW)	4		√	√	√
29.	CONSTRUCTION (CON)	5				
30.	WHOLESALE & RETAIL TRADE (WRT)	6				
31.	RAIL TRANSPORT (RLT)	7A	√	√	√	
32.	OTHER TRANSPORT, STORAGE & COMMUNICATIONS (TSC)	7B				
33.	FINANCE, INS. & REAL EST. (FIR)	8				
34.	COMM., SOCIAL & PERS. SERV. (CSP)	9				

competitive, as well as in the cases of four state monopoly sectors and three administered price manufacturing sectors, products are differentiated by country of origin, *i.e.* whether from India or rest-of-world (ROW). In the monopolistically competitive industries products are differentiated by firm.

Consumers and producers are assumed to use a two-stage procedure to allocate expenditure across differentiated products. The consumer behaviour is depicted in *Figure 1* and that of the producer in *Figure 2*. At the first stage, expenditure is allocated across goods without regard for the country of origin (whether India or ROW) or the producing firm. At this stage, the utility function is taken to be Cobb-Douglas. The production function at this stage requires inputs in fixed proportion. In the second stage, expenditure on monopolistically competitive goods is allocated across competing firms in India and ROW. However, in the case of perfectly competitive goods, individual firm supply is indeterminate. Therefore, expenditure on each good must be allocated over the industry as a whole. The aggregation function in the second stage is the Constant Elasticity of Substitution (CES) function.

In the case of factor markets, the variable input requirements are taken to be the same for the three market structures. Primary and intermediate input aggregates are required in fixed proportion to output. Expenditures on primary inputs are allocated between capital and labour, assuming that a CES function is used to form the primary inputs aggregate. In the case of four agricultural sectors, land (along with capital and labour) is also assumed to be one of the primary factors of production. The primary inputs aggregate in these cases is a CES function of labour and a composite of land and capital. The composite of land and capital is a CES function of land and capital. In the monopolistically competitive sectors as well

Figure 1

CONSUMER'S BEHAVIOUR

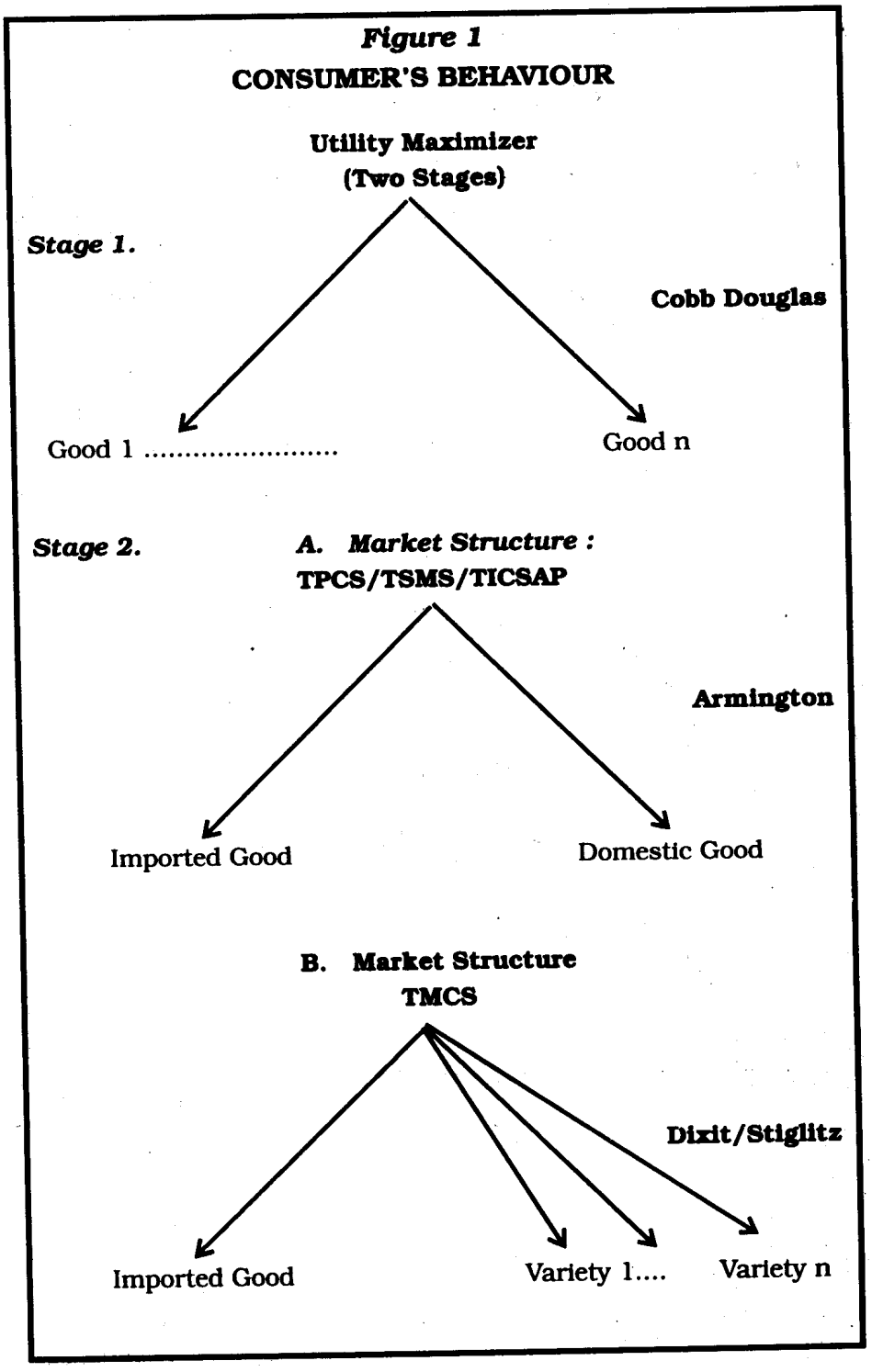
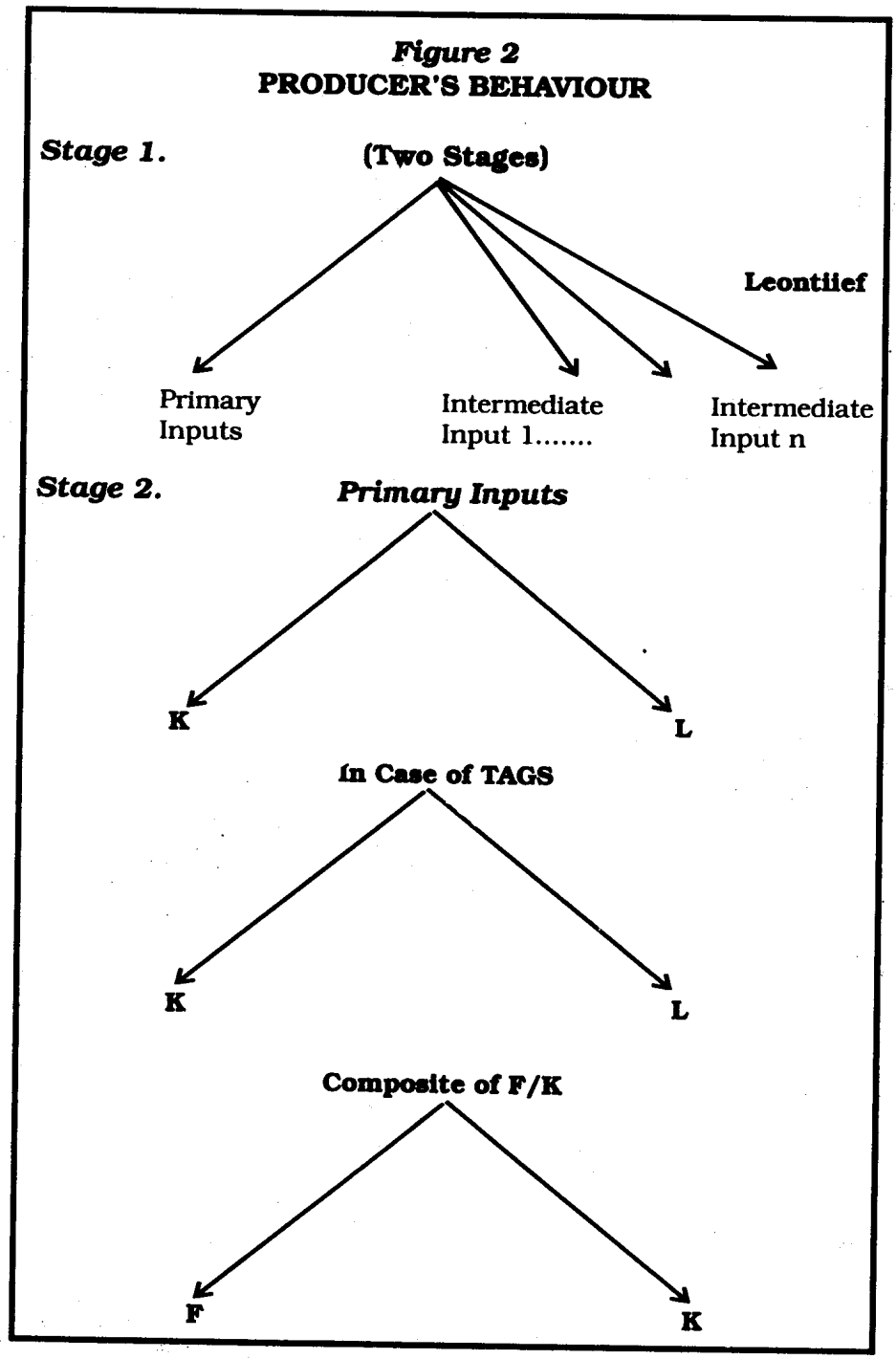


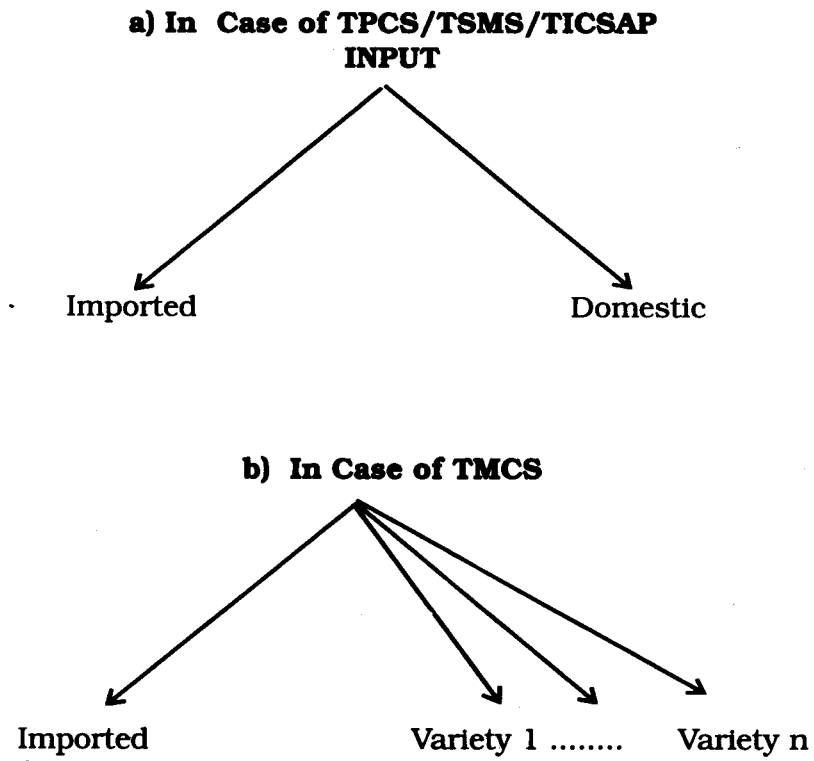
Figure 2
PRODUCER'S BEHAVIOUR



(Continued)

***Figure 2** (Continued)*

Stage 2. ***Intermediate Inputs***



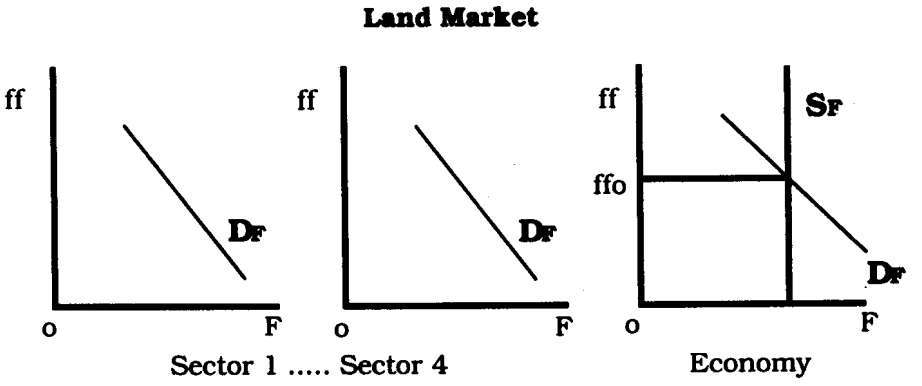
as in the state monopoly sectors, additional fixed inputs of capital and labour are required. It is assumed that fixed capital and fixed labour are used in the same proportion as variable capital and variable labour so that production functions are homothetic. Capital and labour are assumed to be perfectly mobile across sectors except that all capital is assumed to be immobile into and out of the state monopoly sectors. However, we keep the option of specifying sector specific capital for some purposes - especially for short-term analysis. Land usage in agriculture is assumed to be substitutable across four agricultural sectors. Returns to land, capital (in sectors across which it is mobile) and labour are determined to equate factor demand to an exogenous supply of each factor. The aggregate supplies of labour, capital and agricultural land are assumed to remain fixed (*Figure 3*). This assumption is made so as to abstract from macroeconomic forces and focus on intersectoral allocation of resources.

Perfectly competitive firms set price equal to marginal cost, while monopolistically competitive firms maximize profits by setting price as an optimal markup over marginal cost. The number of firms in sectors under monopolistic competition are determined by the condition that there are zero profits. The number of firms in the state monopoly sectors as well as in the three administered price sectors under imperfect competition are assumed to remain fixed.

The profits are assumed to be redistributed to be spent on consumption. International trade in goods by India is assumed to be subject to tariffs and non-tariff barriers (NTBs). NTBs are incorporated by endogenously solving for the ad valorem tariff-equivalent rate that would hold imports within each product category covered by NTBs at a pre-determined level. An ad valorem tariff variable in each product category is

Figure 3

FACTOR MARKETS : FULL EMPLOYEMENT OF RESOURCES



then an average of this NTB tariff-equivalent rate and the nominal tariff rate, using the NTB coverage ratio to weigh the NTB tariff equivalent. Tariff rates are aggregated according to the sectors specified in this model.

In the non-tradable rail transport sector, total demand must equal national output. The prices in this sector are assumed to be set by the government and hence exogenous. For two of the four agricultural sectors, *viz.* other cereals and rest of agriculture (which are under perfect competition), total demand (inclusive of exports) for the sector's product must equal its output. In the case of the remaining two agricultural sectors, paddy and wheat, as well in four tradable state monopoly sectors, the prices are assumed to be administered by the government. In three of the sectors under imperfect competition, *viz.* paper products, fertilizers and non-ferrous metals, the prices have been assumed to be administered.

While analysing the impact of reforms on the economy, we run two different sets of experiments. The first set of simulations is run with retaining the product market restrictions mentioned above in this paper. The second set of simulations is run after relaxing these product market restrictions. It is then assumed that none of the sectors is a state monopoly and that prices are not administered in any of the sectors.

Equations of the India CGE Model

COUNTRY EQUATIONS

A. Final Demand:

Final demand equations for various sectors are derived assuming that all households share a common Cobb-Douglas utility/welfare function as specified in *Function (I)* : [3]

(I) $$U = \prod_{j \in ALS} C_j^{\alpha_j}$$

At this stage, expenditure is allocated across goods without regard for the country of origin or the producing firm. Final demand equations for different sectors are obtained by maximizing the above utility function subject to household income E.[4] *Equation (1)* gives the final demands for all the 34 sectors of Indian economy.

(1) $$\hat{C}_j = \hat{E} - \hat{P}_j \qquad j \in ALS$$

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[3] The set notations are explained in *Table 2*. The list of variables and parameters is given in *Appendix I*. In the text below, we follow the convention that a hat over a variable indicates the change in the logarithm of the variable, or approximately its per cent change. Also, δ before a variable indicates the absolute change in the variable.

[4] *See* Chadha, Djankov and Pohit (1995) for derivational notes.

A constant fraction of the budget is spent on each good since we have assumed a Cobb-Douglas utility function. The per cent change in the demand for a good is therefore the difference between the per cent changes in expenditure and price.

B. *Intermediate Demand:*

To state demands for intermediate inputs from different industries and primary inputs, we assume a Leontief production function of the form given in *Function (II)* :

$$\textbf{(II)} \quad S_k = Min\left[\frac{n_k V_k}{v_{ko}}, \frac{Z_{1k}}{v_{1k}}, \frac{Z_{2k}}{v_{2k}}, \frac{Z_{3k}}{v_{3k}}, \ldots, \frac{Z_{34k}}{v_{34k}}\right] - S_k^o \qquad k \in ALS$$

From *(II)*, the change in intermediate demand for input j by sector k is given in *Equation (2)*. That is, it is assumed that all intermediate inputs are required in fixed proportions to production. The demand for each intermediate input is thus proportional to production. Therefore, if output in sector k rises by 5 per cent, then the use of every single intermediate input from each of the 34 sectors must also rise by 5 per cent.

$$(2) \quad \hat{Z}_{jk} = \hat{S}_k \qquad j/k \in ALS$$

C. *Total Demand:*

Total demand for goods is given in *Equation (3)*. To obtain total demand we begin with household demand for good j. In addition, we must also add intermediate demand for good j by

all the k different sectors. In terms of per cent change, the total change in demand for good j is a weighted average of the per cent changes in final and intermediate demands for good j.

$$(3)\quad \hat{D}_j = v_{jo}\,\hat{C}_j + \sum_{k \epsilon ALS} vd_{jk}\,\hat{Z}_{jk} \qquad j \epsilon ALS$$

D. *Product Demand:*

Aggregates of industry demands are defined identically for both final and intermediate demands as follows:

(a) For tradable sectors under perfect competition, state monopoly and administered prices [Armington: *Function (III)*] :

$$\textbf{(III)}\quad Z_{jk} = [Z_{I_{jk}}^{\rho_j} + Z_{W_{jk}}^{\rho_j}]^{\frac{1}{\rho_j}} \qquad j \epsilon (TPCS) U (TSMS) U (TICSAP), k$$

According to the Armington assumption, product is differentiated by the country of origin. In this model, the countries are India and rest-of-world (ROW).

(b) For tradable sectors under monopolistic competition [Dixit-Stiglitz : *Function (IV)*]:

$$\textbf{(IV)}\quad Z_{jk} = [\sum_{m=1}^{n_j} Z_{I_{mjk}}^{\rho_j} + Z_{W_{jk}}^{\rho_j}]^{\frac{1}{\rho_j}} \qquad j \epsilon TICS, k \epsilon ALS$$

where m stands for firms.

According to Dixit and Stiglitz (1977), the product is differentiated by firm under monopolistic competition. In this model, the product is differentiated by firm in India along with one more variety entering from ROW. Total demand for tradable good j is then broken down into the various import and domestic varieties of good j. First, total demand is allocated between *imports* as given in *Equation (4)* and a *typical domestically produced variety* as given in *Equation (5)*. We assume that the number of firms remain unchanged in nine perfectly competitive sectors (sectors 1 to 4 and 29 to 34 excluding 31) and four public sector monopolies (sectors 16, 20, 27, 28) and three imperfectly competitive price administered sectors (sectors 12, 14, 21).

$$(4)\quad \hat{D}_j^m = \hat{D}_j + \sigma_j\, \theta_j^I\, (\hat{P}_j^I - \hat{P}_j^M) \quad - \quad \frac{\sigma_j\, \theta_j^I}{\sigma_j - 1}\, \hat{n}_j \qquad j \in TRS$$

$$(5)\quad \hat{D}_j^I = \hat{D}_j + \sigma_j\, \theta_j^M\, (\hat{P}_j^M - \hat{P}_j^I) \quad - \quad \frac{\sigma_j\, \theta_j^I}{\sigma_j - 1}\, \hat{n}_j \qquad j \in TRS$$

The last term in *Equations (4)* and *(5)* vanishes for j TPCS U TSMS U TICSAP since $\hat{n}_j = 0$.

As can be seen from the first terms in both equations, the first determinant of import demand and domestic demand is total demand. Assuming that the number of firms and relative prices do not change, if total demand rises by 2 per cent then import and domestic demand each will also rise by 2 per cent.

Of course, if relative prices do change then consumers will reallocate between imports and the domestic variety. If the price of the domestic variety rises relative to imports, then

consumers will certainly substitute away from the domestic good toward imports, as can be seen from the second term in each of the two equations. How much substitution takes place depends on the elasticity of substitution, sigma. The higher the sigma, the more sensitive consumers are to the change in relative prices.

Another force affecting demand for the import aggregate and each of the domestic varieties is the number of domestic firms. As the number of domestic firms rises, the demand for each incumbent firm will fall and demand for the import aggregate will fall as given in *Equations (4)* and *(5)*. That effect is absent in the case of sectors for which $\hat{n}_j = 0$.

E. Prices:

There are various price relationships that must hold in the model including one that is merely definitional as given in *Equation (6)*. *Equation (7)* specifies that the per cent changes in prices of domestic variety as well as the rupee price of imported variety of the sectors under administered prices are simply equal to the corresponding changes in their administered prices.

$$(6) \quad \hat{P}_j = \theta_j^I \hat{P}_j^I + \theta_j^M \hat{P}_j^M - \frac{\theta_j^I \hat{n}_j}{\sigma_j - 1}, \qquad j \in TRS$$

$$(7) \quad \hat{P}_j = \hat{P}_j^o \qquad j \in NTS$$
$$\hat{P}_j^I = \hat{P}_j^o \qquad j \in TAPS$$
$$\hat{P}_j^M = \hat{P}_j^o \qquad j \in TAPS$$

The last term in *Equation (6)* vanishes for $j \varepsilon TPCS \cup TSMS \cup TICSAP$ *since* $\hat{n}_j = 0$. It may be observed that the number of

varieties enters negatively in *Equation (6)*. As the number of varieties rises, the price index falls. This is because consumers like variety. The greater the number of firms the more the variety available to consumers. Therefore, consumers can achieve a certain level of utility at a lower cost if more varieties are available. Thus whereas P_j^I is the change in price of a physical unit of good j produced in India, $P_j^I - \hat{n}_j (j - 1)$ is the price of acquiring a unit of utility from the varieties of goods produced in India. P_j^M and P_j are similarly defined in terms of utility.

The sensitivity of the price index to the number of varieties depends on the elasticity of substitution. The lower the sigma the more the price index falls when new varieties are introduced. A low sigma implies that varieties are very different from one another, that is, addition of a new variety brings a lot of additional value to the consumer. Thus, there is a large decline in the implicit cost of achieving a particular level of utility from consumption.

The next two equations, *(8)* and *(9)*, link world prices to domestic prices. *Equation (8)* simply states that the landed price of imports from rest of the world is determined by the world price of goods produced abroad, the exchange rate (rupees per dollar) and the tariff equivalent. *Equation (9)* states that the domestic price of a typical variety is determined by the domestic currency equivalent of the price at which India exports to the world markets.

$$(8) \qquad \hat{P}_j^M = \hat{P}_{Wj}^W + \hat{R} + \hat{t}_j^{Meq} \qquad j \in TRS$$

$$(9) \qquad \hat{P}_{Wj}^I = \hat{P}_j^I - \hat{R} + \hat{t}_j^{Xeq} \qquad j \in TRS$$

Equation (10) relates to the sectors under perfect competition. The price of each of these sectors must be equal to marginal cost inclusive of the net production tax. *Equation (11)* states that per cent change in price of a domestic variety for tradable public sector monopolies must be equal to marginal cost inclusive of net production tax. *Equation (12)* specifies that per cent changes in the prices of non-traded sectors under administered prices are equal to the sum of corresponding changes in their administered prices and premium due to supply shortages.

$$\text{(10)} \qquad \hat{P}_j^I = \hat{MC}_j \qquad j \in TPCS$$

$$\text{(11)} \qquad \hat{P}_j^I = \hat{MC}_j \qquad j \in TSMS$$

$$\text{(12)} \qquad \hat{P}_j^I = \hat{MC}_j + \hat{PR}_j \qquad j \in NSMS$$

Equation (13) states that price must be equal to total cost for sectors under imperfect competition.

$$\text{(13)} \qquad \hat{P}_j^I = \theta_j^{MC}\,\hat{MC}_j + \theta_j^{FC}\,(P_j^V + \hat{n}_j - \hat{S}_j) \qquad j \in TICS$$

$$\hat{n}_j = 0 \qquad j \in TICSAP$$

Imperfectly competitive firms in sectors in which entry occurs, must also charge the optimal mark-up over marginal cost, inclusive of net production tax, as can be seen from *Equation (14)*. The optimal mark-up depends on the elasticity

of demand. The higher the elasticity (in absolute value), the smaller the gap between price and marginal cost.

$$(14) \qquad \hat{P}_j^I = \hat{MC}_j + \frac{\hat{\eta}_j}{\eta_j + 1} \qquad j \in TMCS$$

Finally, the price of the primary inputs aggregate (value added) is given in *Equation (15)*. For all the sectors except the four agricultural sectors, this price is the cost-share-weighted average of the returns to primary inputs, capital and labour. However, in the case of four agricultural sectors, the price of the primary inputs aggregate is given in *Equation (16)* as a weighted average of the returns to the capital-land composite and the wage rate. *Equation (17)* gives price of the capital-land composite.

$$(15) \qquad \hat{P}_j^V = \theta_{j1}^L \hat{w} + \theta_{j1}^K \hat{r}_j \qquad j \in (TAGS)^C$$

$$(16) \qquad \hat{P}_j^V = \theta_{j2}^{KF} \hat{P}_j^{KF} + \theta_{j2}^L \hat{w} \qquad j \in TAGS$$

$$(17) \qquad \hat{P}_j^{KF} = \theta_{j3}^k \hat{r}_j + \theta_{j3}^F \hat{r} \qquad j \in TAGS$$

$$\hat{r}_j = \hat{r} \qquad j \in (SMS)^C$$

F. *Marginal Cost and Average Cost:*

There are two components of marginal cost as given in *Equation (18)*. The first term is the cost of primary inputs (capital

and labour, and land as an additional factor in agricultural sectors) and the second term is the intermediate inputs from all of the goods sectors.

$$(18)\quad \hat{MC}_j = b_{jo}\,\frac{\theta_j^{VK}}{\theta_j^{MC}}\,\hat{P}_j^V + \sum_{k\epsilon ALS}\frac{b_{kj}}{\theta_j^{MC}}\,\hat{P}_k + bt_j\,\hat{NT}_j \qquad j \in ALS$$

$$\theta_j{}^{VK}=\theta_j{}^{MC}=1 \qquad for\ \ j \in TPCS\ U\ TSMS\ U\ NTS$$

It is worth pointing out here something on the nature of technology. As will be seen later, marginal cost is made up of the cost of labour, capital and intermediate inputs. However, labour and capital are the only fixed inputs. No intermediate inputs are required for fixed costs. The cost of fixed labour and capital inputs is captured by P_j^v given in the second term of *Equation (18).*

G. *Demand for Primary Inputs:*

Aggregates of industry demands for primary inputs are given in *Functions (V), (VI),* and *(VII)*:

$$\textbf{(V)}\quad V_j = [\ L_j^{\rho_j^1} + K_j^{\rho_j^1}\ ]^{\frac{1}{\rho_j^1}} \qquad j \in (TAGS)^C$$

$$\textbf{(VI)}\quad V_j = [\ L_j^{\rho_j^2} + KF_j^{\rho_j^2}\ ]^{\frac{1}{\rho_j^2}} \qquad j \in TAGS$$

$$\textbf{(VII)}\quad V_j = [\ K_j^{\rho_j^3} + F_j^{\rho_j^3}\ ]^{\frac{1}{\rho_j^3}} \qquad j \in TAGS$$

Capital and labour are combined to form a primary input aggregate in the case of all sectors except four agricultural

sectors where we consider land to be an additional primary factor of production. The primary input aggregate is then used in fixed proportion to firm output. This is shown in *Equation (19)* for a representative firm under imperfect competition. *Equation (20)* corresponds to all other sectors including nine sectors under perfect competition and five public monopoly sectors.

$$(19) \quad \hat{V}_j = \hat{S}_j - \hat{n}_j \qquad j \in TMCS$$

$$(20) \quad \hat{V}_j = \hat{S}_j \qquad j \in (TMCS)^c$$

Once the demand for the primary inputs aggregate has been determined, expenditure is then allocated between capital and labour for all sectors except agriculture, in which land is an additional primary factor. This is given in *Equation (21).* Return to capital is the same for sectors across which capital is mobile but is sector specific for sectors in which it is immobile.

$$(21) \quad \hat{L}_j = \theta_j^{VK} \hat{V}_j - \overline{\sigma}_{j1} \theta_{j1}^{k} (\hat{w} - \hat{r}_j) + \hat{n}_j \qquad j \in (TAGS)^c$$

$$\hat{n}_j = 0 \qquad j \in (SMS) U (TNAGS) U (TICSAP)$$

$$\theta_j^{VK} = 1 \qquad j \in TNAGS \; U \; NSMS$$

$$\hat{r}_j = \hat{r} \qquad j \in (TMCS) \; U \; (TICSAP) \; U \; (TNAGS)$$

For sectors j = 1..4 (TAGS), we would write a separate labour demand function in *Equation (25).*

The demand for capital for all sectors, except agriculture, is given in *Equation (22),* which is analogous to *Equation (21)*

for labour demand. As given in *Equation (23)*, it is assumed that the capital stock remains fixed for five public monopoly sectors (four tradable and one non-traded).

$$(22)\quad \hat{K}_j = \theta_j^{VK}\,\hat{V}_j + \overline{\sigma}_{j1}\,\theta_{j1}^{L}\,(\hat{w} - \hat{r}_j) + \hat{n}_j \qquad j \in (TAGS)^C$$

$$\hat{n}_j = 0 \qquad j \in (SMS)\,U(TNAGS)\,U(TICSAP)$$

$$\theta_j^{VK} = 1 \qquad j \in TNAGS\ U\ NSMS$$

$$\hat{r}_j = \hat{r} \qquad j \in (TMCS)\,U(TICSAP)\,U(TNAGS)$$

$$(23)\quad \hat{K}_j = 0 \qquad j \in SMS$$

For sectors j = 1..4 (TAGS), we would write a separate capital demand function in *Equation (26)*.

We assume that land is an additional primary factor of production, apart from capital and labour, in the case of the four agricultural sectors. The primary inputs aggregate is a CES function of labour and a composite of land and capital. The land-capital composite is, in turn, a CES function of land and capital. The demand for the land-capital composite, as given in *Equation (24)*, depends on the demand for the primary inputs aggregate and the relative price of labour and land-capital composite. *Equation (25)* provides the corresponding demand for labour. *Equations (26)* and *(27)* provide demands for capital and land, respectively, each depending on the land-capital composite and relative prices of capital and land.

$$(24)\quad \hat{KF}_j = \hat{V}_j - \overline{\sigma}_{j2}\,\theta_{j2}^{L}\,(\hat{P}_j^{KF} - \hat{w})$$

$$(25) \quad \hat{L}_j = \hat{V}_j + \overline{\sigma}_{j2}\, \theta^{KF}_{j2}\, (\hat{P}^{KF}_j - \hat{w})$$

$$(26) \quad \hat{K}_j = K\hat{F}_j - \overline{\sigma}_{j3}\, \theta^{F}_{j3}\, (\hat{r}_j - \hat{f})$$

$$(27) \quad \hat{F}_j = K\hat{F}_j + \overline{\sigma}_{j3}\, \theta^{K}_{j3}\, (\hat{r}_j - \hat{f})$$

$$\hat{r}_j = r$$

$$j \in TAGS$$

H. *Non-Tradable Goods Market Equilibrium:*

Market clearing in non-tradable rail transport sector requires that domestic demand equals domestic supply, as given in *Equation (28)*.

$$(28) \quad \hat{S}_j = \hat{D}_j \qquad j \in NTS$$

I. *Demand Elasticity:*

The demand elasticity for tradable goods under imperfect competition is given in *Equation (29)*. The demand curve will be perceived as more elastic if the number of competing firms rises or the world prices of competing goods fall relative to the domestic goods.

$$(29) \quad \hat{\eta}_j = \frac{(\sigma_j - 1)}{\eta_j\, n_j}\, \theta^{I}_{j}\, (\hat{D}^{I}_j + \hat{P}^{I}_j - \hat{P}_j - \hat{D}_j) \qquad j \in TMCS$$

J. Primary Factors Market Equilibrium:

Capital, labour and land markets clear when the sum over industry demand for each factor equals an exogenous supply. The relevant factor market equilibrium conditions are given in *Equations (30), (31)* and *(32)*, respectively.

$$(30) \qquad \sum_{j \in ALS} h_j^K \hat{K}_j = \hat{K}^o$$

$$(31) \qquad \sum_{j \in ALS} h_j^L \hat{L}_j = \hat{L}^o$$

$$(32) \qquad \sum_{j \in TAGS} h_j^F \hat{F}_j = \hat{F}^o$$

where h_j^K, h_j^L and h_j^F are the fractions of K, L and F, respectively, employed in industry j.

K. Non-Tariff Barriers:

There are two types of trade barriers that affect imports, nominal tariffs and quantitative restrictions (QRs), *i.e.* non-tariff barriers (NTBs). Each QR is captured by its endogenous tariff equivalent. The tariff equivalent is calculated endogenously in the model so that if demand or supply conditions change then the tariff equivalent will also change to hold the quantity demanded as constant.

The actual tariff that applies is then composed of the nominal tariff (first term in *Equation (33)* and the tariff equivalent of the non-tariff barrier (second term). The QRs are invoked by specifying the fraction of the sector covered by NTBs,

and the desired change in the QRs, Q_j. *Equation (34)* specifies the export tax equivalent imposed by India on exports to ROW. The first term in *Equation (34)* relates to the nominal export tax while the second term measures the export tax equivalent of the non-tax barriers to exports from India to ROW.

$$(33) \qquad \hat{t}_j^{Meq} = \hat{t}_j + (\hat{D}_j^M - \hat{Q}_j^M) \frac{\theta_j^{MQ}}{\sigma_j(1 - \theta_j^{MQ})}$$

$$j \in TMCS \cup TNAGS \cup TAGSNA$$

$$(34) \qquad \hat{t}_j^{Xeq} = \hat{t}_j^x + (\hat{D}_{jR} - \hat{Q}_j^x) \frac{\theta_j^{XQ}}{\eta_j^R(1 - \theta_j^{XQ})} \qquad j \in TRS$$

$$\hat{n}_j = 0 \qquad j \in TPCS \cup TSMS \cup TICSAP$$

Equation (35) specifies that the domestic price of 'food' sector is taken as numeraire and put equal to 1.

$$(35) \qquad \hat{P}_5^I = 0$$

L. *Demand for India's Exports to ROW:*

The export demand for a tradable good from India to ROW depends on India's price and the demand elasticity for India's exports. This is given in *Equation (36)* for all tradable sectors.

$$(36) \qquad \hat{D}_{jR}^I = \eta_j^R \hat{P}_{Wj}^I \qquad j \in TRS$$

M. Trade Balance:

The trade balance (in dollar terms) is the sum over changes in the value of exports *less* changes in the value of imports. This is given in *Equation (37).*

$$(37) \quad \delta B^T = \sum_{j \in TRS} D^I_{jR} P^I_{Wj} (\hat{D}^I_{jR} + \hat{P}^I_{Wj}) - \sum_{j \in TRS} D^M_j P^W_{Wj} (\hat{D}^m_j + \hat{P}^W_{Wj})$$

N. Tradable Goods Market Equilibrium:

The market for each tradable good in India merely requires that total supply should be equal to total world demand. Total world demand includes demand originating in India *plus* that in ROW. This is given in *Equation (38).*

$$(38) \quad S_j \hat{S}_j = D^I_{jR} \hat{D}^I_{jR} + D^I_j n_j (\hat{D}^I_j + \hat{n}_j) \qquad j \in TRS$$
$$\hat{n}_j = 0 \qquad j \in TPCS \ U \ TSMS \ U \ TICSAP$$
$$n_j = 1 \qquad j \in TPCS \ U \ TSMS$$

O. Exchange Rate Determination:

Exchange rates are determined in *Equations (39)* and *(40),* with separate cases for fixed and flexible exchange rate regimes. If we consider India to be on pegged exchange rate system,

Equation (39) sets it exogenously with respect to the US dollar. But, if India adopts a flexible exchange rate, *Equation (40)* determines it by the requirement that its balance of trade *plus* an exogenous capital inflow be equal to zero.

(39) $\hat{R} = \hat{R}^{o}$

(40) $\delta B^{T} + \delta B^{ko} = 0$

Appendix I

INDIA CGE MODEL

List of Exogenous Variables of the Model

B^{Ko}	:	Exogenous level of capital inflow in India	
F^o	:	Supply of agricultural land in India	
K^o	:	Capital stock in India	
K_j	:	Fixed capital stock in sector j	(j ∈ SMS)
L^o	:	Labour supply in India	
NT_j	:	Net production tax on good j	(j ∈ ALS)
$P_{wj}{}^w$	:	World price of good j	(j ∈ TRS)
Q_j^M	:	Quota restriction on imports of good j by India	(j ∈ TRS)
Q_j^X	:	Restriction on exports of good j by India	(j ∈ TRS)
$S_k{}^o$	:	Fixed cost parameter in industry j	(j ∈ ALS)
R^o	:	Exogenous level of exchange rate of rupee vis-a-vis dollar	
t_j	:	One plus tariff imposed by India on imports of good	(j ∈ TRS)
t^X_j	:	One plus tariff imposed by India on exports of good	(j ∈ TRS)
n_j	:	Number of firms in industry j in India	(j ∈ TSMS U TICSAP U TPCS)

List of Endogenous Variables of the Model

B^T	:	India's trade balance	
C_j	:	Final demand for good j in India	(j ∈ ALS)
n_j	:	Number of firms in industry j in India	(j ∈ TMCS)
D_j	:	Total demand for good j in India	(j ∈ ALS)
D_{JR}^I	:	Demand for good produced in India by ROW	(j ∈ TRS)
D_j^I	:	Demand in country i of the good produced by a representative firm in industry j in India	(j ∈ TRS)
D_j^M	:	Total demand for imports of good j in India	(j ∈ TRS)
E	:	Aggregate nominal expenditure	
η_j	:	Perceived elasticity of demand by a representative firm in industry j in India	(j ∈ TMCS)
F_j	:	Demand for land in sector j in India	(j ∈ TAGS)
f	:	Return to land in India	
K_j	:	Demand for capital in industry j in India	(j ∈ SMS_C)
KF_j	:	Demand for aggregate of land and capital in sector j	(j ∈ TAGS)

L_j : Demand for labour in industry j in India ($j \in ALS$)

MC_j : Marginal cost in India of industry j or of a representative firm in industry j ($j \in ALS$)

P_j^M : Price index of imported good j in India ($j \in TRS$)

P_j^I : Price of domestic good produced by a representative firm in industry j in India ($j \in TRS$)

P_j : Price index of good j in India ($j \in ALS$)

P_j^o : Administered price of tradable good j ($j \in APS$)

P_{wj}^I : World price of good j produced in India ($j \in TRS$)

P_{w5}^I : World price of numeraire good (food) produced in India

P_j^V : Price Index of primary input aggregate (i.e. labour and capital or labour and composite of land and capital) in industry j in India ($j \in ALS$)

P_j^{KF} : Price index of Ist stage primary input aggregate (i.e. labor and composite of capital & land) in sector j in India ($j \in TAGS$)

PR_j : Premium over price in industry j ($j \in NSMS$)

r : Return to capital in India in equilibrium

r_j : Return to capital in India in industry j ($j \in ALS$)

R : Exchange rate of Rupee vis-a-vis dollar

S_k : Production of good k in India ($k \in ALS$)

t_j^{Meq} : One plus tariff equivalent in industry j imposed by India on imports from ROW ($j \in TRS$)

t_j^{Xeq} : One plus export tax equivalent imposed in industry j by India ($j \in TRS$)

V_j : Primary input aggregate demanded by a representative firm in industry j in India ($j \in ALS$)

w : Wage paid to labour

Z_{jk} : Aggregate of sectoral inputs from industry j into industry k (aggregation of industries and or firms) ($j/k \in ALS$)

Z_{ijk} : Intermediate demand for tradable good j of Indian origin by industry k in India ($j \in TPCS \cup TSMS$, $k \in ALS$)

Z_{Wjk} : Intermediate demand for tradable good j of rest of world's origin by industry k in India ($j \in TPCS \cup TSMS$, $k \in ALS$)

Z_{Imjk} : Intermediate demand for tradable good j of Indian origin by a representative firm in industry k in India ($j \in TICS$, $k \in ALS$)

List of Parameters of the Model

α_j : Fraction of budget spent on good j ($j \in ALS$)

b_{jo} : Primary input share of total cost in industry j in India ($j \in ALS$)

b_{jk} : Intermediate input k's share of total cost of production in industry j in India ($j/k \in ALS$)

bt_j : Tax share of total cost in industry j in India ($j \in ALS$)

h_j^K : Fraction of capital in India employed in industry j ($j \in ALS$)

h_j^L : Fraction of labour in India employed in industry j ($j \in ALS$)

h_j^F : Fraction of land in India allocated to sector j ($j \in TAGS$)

v_{jo} : Primary inputs (value-added) per unit output of good j ($j \in ALS$)

v_{jk} : Intermediate demand for good j per unit output of industry k ($j/k \in ALS$)

v_{jo} : Final consumption share of total purchases of good j in India ($j \in ALS$)

vd_{jk} : Intermediate demand for good j by industry k share of purchases of good j in India ($j/k \in ALS$)

θ_j^M : Fraction of expenditure on good j in India devoted to imports ($j \in TRS$)

θ_j^I : Fraction of expenditure on good j in India devoted to goods produced in India ($j \in TRS$)

θ_j^{MQ} : Fraction of imports of goods j by India that are subject to quantitative restriction ($j \in TRS$)

θ_j^{XQ} : Fraction of exports in industry j that are subject to quantitative restriction ($j \in TRS$)

θ_j^{MC} : Variable input share of total cost in industry j in India ($j \in ALS$)

θ_j^{FC} : Fixed cost share of total cost in industry j in India ($j \in TICS$)

θ_{j1}^{L} : Labour's share of expenditure on primary inputs in industry j in India ($j \in TAGS^c$)

θ_{j2}^{L} : Labour's share of expenditure on first stage aggregate of primary inputs in sector j in India ($j \in TAGS$)

θ_{j2}^{KF} : Composite of land and capital's share of expenditure on first stage aggregate of primary inputs in sector j in India ($j \in TAGS$)

θ_{j1}^{K} : Capital's share of expenditure on primary inputs in industry j in India ($j \in TAGS^c$)

θ_{j3}^{K} : Capital's share of expenditure on second stage aggregate primary inputs in sector j in India ($j \in TAGS$)

θ_{j3}^{F} : Land's share of expenditure on second stage aggregate of primary inputs in sector j in India ($j \in TAGS$)

θ_j^{VK} : Variable capital's share of total cost in industry j in India ($j \in ALS$)

ρ_j : $1/(1-\bar{\sigma}_j)$ ($j \in TRS$)

ρ_j^1 : $1/(1-\bar{\sigma}_{j1})$ ($j \in TAGS^c$)

ρ_j^2 : $1/(1-\bar{\sigma}_{j2})$ ($j \in TAGS$)

ρ_j^3 : $1/(1-\bar{\sigma}_{j3})$ ($j \in TAGS$)

$\bar{\sigma}_j$: Elasticity of substitution between imported and varieties of good j produced by representative firms/ industry in India ($j \in TRS$)

$\bar{\sigma}_{j1}$: Elasticity of substitution between capital and labour in industry j in India ($j \in TAGS^c$)

$\bar{\sigma}_{j2}$: Elasticity of substitution between labour and composite of capital and land in sector j in India ($j \in TAGS$)

$\bar{\sigma}_{j3}$: Elasticity of substitution between capital and land in sector j in India ($j \in TAGS$)

η_j^R : Demand elasticity of India's export of good j ($j \in TRS$)

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