General Equilibrium Analysis of Strategic Trade : A CGE Model for India

Koushik Das
Assistant Professor, Department of Economics
Chandias Mahavidyalaya

Pinaki Chakraborti
Professor, Department of Economics, Burdwan University.

Abstract

Strategic trade refers to international trade under market imperfections. The purpose of the paper is to comprehend general equilibrium implications of trade liberalization on Indian macroeconomic aspects under alternative market structures. We applied Computable General Equilibrium (CGE) modelling as our relevant methodology following Shoven, J.B. and Whalley, J (1984). Constructing a four sector Social Accounting Matrix (SAM) for India paper attempts to purport the effects of liberalized trade over different macroeconomic aspects under monopolistic competition and compared the results with the same obtained under benchmark perfect competition scenario. Our study reveals that trade under imperfect competition could not produce any greater domestic output, expansion of trade in terms of volume of export & import and gains from trade as compared to standard perfect competition scenario.

Keywords: CGE, SAM, Monopolistic Competition, Trade liberalization.

1. Introduction

This paper attempts empirical implementation of a real trade general equilibrium model using computable general equilibrium methodology for a small open economy that includes some features related to "industrial organization" approach to trade. Theoretical study in this area has been developed rapidly by the works of Helpman(1981,1982) , Krugman(1979,1980,1981)   and many others dealing with imperfect competition, economies of scale, entry barriers, product differentiation and few other aspects of industry structure while judging costs and benefits of trade liberalization. Very early works of Bela Balassa(1966) , W.M. Corden(1972,1974) , H.C. Eastman and S. Stykolt(1966) and Ron Wonnacott and Paul Wonnacott(1967) studied the role of scale economies and its impact on international trade and structure of the industry. Balassa(1966) and Grubel and P.J. Loyed (1975) reported that much trade takes place on intra-industry basis which provides solid foundation for inter industry and intra-industry adjustment along with Hecksher-Ohlin argument of comparative cost advantage.

   Argument from Industrial Organisation (IO) standpoint predicts that imposition of trade barriers restrict market size and foreign competition promoting too many home firms to operate in an industry exploiting too low scale of production   (See Krugman 1994, ch. 14). Conventional analysis under perfect competition and constant return to scale predicts the cost of protection to be very small in the order of .5 to 2% of the GDP. This empirical result is confirmed by Robin Boardway and John Treddnick(1978), A., Fred Brown and John Whalley(1980) , A. Deardorff, R.M. Stern (1981), P. Dixon(1981), J. Williams(1976) etc. based on the assumption of perfect competition. Contrary to those analysis Balassa(1966) and Wonnacott(1975) reported much more

higher gains from trade liberalization , obtained under the presence of scale economies and market imperfection than under conventional perfect competition based analysis.

Trade theory and industrial policies are such kind of economic policy which highly depends on general equilibrium structure of the economy. While conventional trade theory highly depends upon Heckswer/Ohlin framework, I/O approach is highly predominant towards partial equilibrium framework. Theoretical works of James Brander (1981), E. Helpman(1981) , Paul Krugman(1980) , Kelvin Lancaster (1980) have been most important in this direction. Dealing with I/O approach to trade with empirical general equilibrium framework is likely to provide insightful implications. Important thing in the general equilibrium set up of the open economy trade structure including I/O features is the assumption of inter sectoral circular flows of commodities and basic factor services which is supposed to capture additional source of comparative cost advantage due to the presence of scale economy benefit along with other conventional sources like geographical factor endowment difference and technology difference.

Haris and Cox (1984) first constructed an empirical general equilibrium model of small open economy that incorporates many I/O features, seems to be important for an industry in a real economy such as Semiconductor industry in U.S.A. and Japan (See Baldwin and Krugman 1988). Their empirical general equilibrium model followed the methodology used by John Shoven and Whalley(1983). Many such works in this direction established the fact that empirical results of a general equilibrium analysis incorporating I/O features differs significantly from the analysis that does not incorporate I/O features[1]. Perfectly competitive structure assumed in many CGE models usually understates gains from trade originated from the reduction of trade barriers. Empirical study of Cox and Harris(1992), Brown and Stern(1989) have shown that incorporation of imperfectly competitive sectors within CGE framework leads to substantial increase of welfare gains for Canada from US-Canada free trade agreement.

In Indian context, noteworthy works on CGE modelling, like Panda and Quizon(2001), Panda et al. (2008), Parikh et el. (1997) did not consider market imperfection explicitly in their empirical general equilibrium analysis. Several strategic aspects like, economies of scale and scope, competition among firms, product differentiation due to consumer's preference for varieties may give rise to different trade policy implications in a general equilibrium framework. In this paper our intention is to introduce market imperfection explicitly in a benchmark perfect competition model and study the consequent trade policy implications.

2. Social Accounting Matrix

CGE models are traditionally based on SAM which is matrix representation of all transactions and transfers that takes place between different production activities, various factors of production and different institutions like households, corporate and government within the country and with respect to rest of the world in a particular financial year. SAM therefore defines a comprehensive framework that can depict full circular flow of income from production activities to factor service providers like households. Each row of a SAM represents total receipts of any account and column represents expenditure of that account. Therefore row total is supposed to be equal with corresponding column total. An entry in the i^{th}row and j^{th} column represents receipts of ith account from the jth account.

Table-1 Schematic structure of SAM

		Activities	Commodities	Factors	Households	PVT Corp.	Pub.Ent	Govt.	Ind. taxes	Capital A/C	ROW	Total
		1	2	3	4	5	6	7	8	9	10	
1	**Activities**		Gross output									Output
2	**Commodities**	Purchase of raw material			Household consumption			Govt. consumption		Gross Fixed Capital Formation	Exports	Aggregate demand
3	**Factors**	Value added									Net factor income	Factor Income
4	**Household**			Endowment Of HH				Govt. transfer,			Net current transfer	Total Household income
5	**PVT corp.**			Operating Profits				Interest on debt				Income of Private Corporate
6	**Pub. Ent.**			Operating Surplus								Income of Public departmental
7	**Govt.**			Income from entrepr.	Income tax by households	Corporate taxes			Total indirect taxes		Net capital transfer	Total govt. earnings
8	**Ind. tax**	Taxes on intermediate			Taxes on purchases			Taxes on purchases		Taxes on investment	Tax on exports	Total Indirect taxes
9	**Capital A/C**			Depreciation	Household savings	Corporate savings	Public sector Savings	Govt. savings			Foreign savings	Gross savings of economy
10	**ROW**		Imports									Foreign exchange payments
	Total	Total cost of production	Aggregate supply	Total factor endowments	Total use of HH income	PVT CORP income	Income of PSU	Aggregate govt. exp.	Total ind. tax	Aggregate investment	Foreign Ex. Recpt.	

Source: Shaluja and Yadav(2006)

A SAM is a database and extension over input/output matrix (I/O). Use of I/O matrix is widely accepted with the pioneering work of Wassily Leontief. I/O matrix however, does not represent interrelationship between factor value added and agent's final expenditure. Extension of an I/O table with the introduction agent's behavior and institutional characteristics one can get essential features of a SAM. This can depict entire circular flow of income much more effectively.

Our environmental CGE model is based on schematic structure of SAM and for calibration of the model we constructed Energy /Environmental SAM for India for the year 2003-04 following Saluja and Yadav(2006)[2] .

3. Structure of Benchmark CGE Model Under Perfect Competition

Our benchmark CGE model is based on Perfect Competition and constant returns to scale assumption both in commodity market and factor market. Model is based on following assumptions.

Sectors and agents: Following SAM for India of the year 2004 produced by Saluja&Yadav(2006) and Ojha V.P. ,Pohit S. et al.(2008) we grouped all sectors of the economy into four aggregated sectors i.e. *1) Primary sector* consists of all agricultural products, minerals , primary products such as iron ores , crude petroleum and agro process activities *2)Secondary sector* is comprised mainly of all manufacturing activities like , cotton & textile , plastic , rubber and lather products, cement ,different chemical products etc. *3) Infrastructural service* consists infrastructural service activities like Water supply, Travel and Transport, Railway, Hotel and Restaurant and Construction. *4) Other service sectors* like education , health care services , public administration , bank and insurance , postal services etc .We considered four types of agents in the economy i.e. a) Household b) Firm c) Government and d) Rest Of the World (ROW).There are four types of households i.e. i) RHH-1(Rural agricultural and other laborers) ii) RHH-2(Agricultural self employed and other households)iii) UHH-1(Urban salaried class) andiv) UHH-2(Urban casual labour and others).All other countries and regions are clubbed together into ROW.

Production and Factor inputs: We have considered two basic factors of production i.e. labour and capital that take part in the production process within which substitution is possible through Cobb-Dauglus production technology. Each production unit requires intermediate inputs following fixed coefficient type Liontief technology.

Prices: Product prices are determined from the equality of price and average cost. Average cost is comprised of basic factor cost, cost of intermediate inputs that includes cost of energy inputs. Increasing returns to scale is assumed through the presence of fixed cost in the production units.

Household income & expenditure: Households are rendering factor services in terms of labour and capital while in return they are receiving factor payments in the form of wages and rentals. We have considered four types of household, two of them are rural type and other two are urban type. Household spends his income for consumption purposes. We have assumed linier expenditure system type demand function for household.

Government income & expenditure: Source of income of the Government is a) Direct, indirect and corporate taxes b) Import tariff [3] c) Income from entrepreneurial activity. In the expenditure front we assumed government's expenditure in any sector is exogenously determined i.e. determined in the government's budget and adjusted to benchmark SAM. Difference between government's income and expenditure is government's savings[4].

Investment & Savings: We considered Neo-classical type closure rule where investment is guided by saving. Total saving is comprised of i) Household saving ii) Government saving iii) Corporate saving iv) Foreign savings. Total saving is converted to total investment.

Armington function and trade: International trade in our model is guided by Armington function. Total availability of composite commodity in the domestic economy is composed of

domestically produced variety of the good demanded by the domestic people and foreign variety of the same good. Both types of variety is combined together following a Constant Elasticity of Substitution type preference function.

Production of output and transformation: Total supply of each domestic good produced using labour, capital and intermediate input is used up by export of that good and to meet up domestic demand of domestic variety. Both export and domestic demand of the produced good is combined together following CES type transformation function.

Factor prices and equilibrium: We consider two basic factors of production i.e. labour and capital. Total supply of basic factor is fixed in value terms and factor prices are flexible. Physical quantity of labour or capital may change in different simulation experiments following demand and supply equilibrium mechanism in the factor market. Demand for factor is originated from the production of goods and services.

Equilibrium in commodity market: In the commodity market total supply of the composite commodity is constituted by domestic variety as well as imported foreign variety corresponds to each good. Demand for the composite commodity is generated from household consumption, government consumption expenditure, total investment demand and demand for intermediate input. Composite commodity price is determined from the demand and supply of composite commodity.

GDP and Welfare: Under perfect competition GDP has been computed adding all sectoral outputs. Social welfare has been of Cobb-Duaglus type and depends on private household consumption.

4. Inclusion of Market Imperfection in CGE Model

In our analysis we assumed presence of fixed cost in the production sector which gives rise to economics of scale at the firm level enabling the firms to have sufficient market power in respect of price setting. Firms may act cooperatively or non-cooperatively. In this point we have been restricted to non-cooperative behaviour of firms only as we followed Krugman and Helpman(1985)[5] essentially.

The outcome of non-cooperative behavior of firms in an industry depends on two factors: a) Strategic aspects of non-cooperation b) Condition of entry and exit in the industry. Most of the theoretical works on trade models incorporating oligopoly[6] considered either output decision or price decision as strategic variables. In our analysis we followed Monopolistic Competition approach based on the assumption of Bertrand-type Competition where each firm takes rival's price as given while taking decision over his own price. We also assume, firms are able to differentiate their products such that products are not perfect substitute for those products of existing competitors as well as potential entrants. Here each firm is acting as monopolist facing downward sloping demand curve. Regarding entry we assumed no barriers to entry or free entry that drives profit to zero. This is known as Chemberlin's "large group" case which is quite consistent with Bertrand model.

Inclusion of Fixed Cost

We modelled fixed cost as the part of total cost which is invariant to output. In actual practice it is not the 'sunk' cost but a recurrent expenditure must be incurred by the firms in each year to carry on production process. For example: maintenance cost of building & construction, machinery,

various equipments[7] etc. We further assume certain part of the total capital cost is fixed cost which is independent of output. Presence of fixed cost implies, higher output production reduces per unit capital cost. This gives sufficient market power to the existing farms. According to our assumption scale economy is external to the firms but internal to the industry[8].
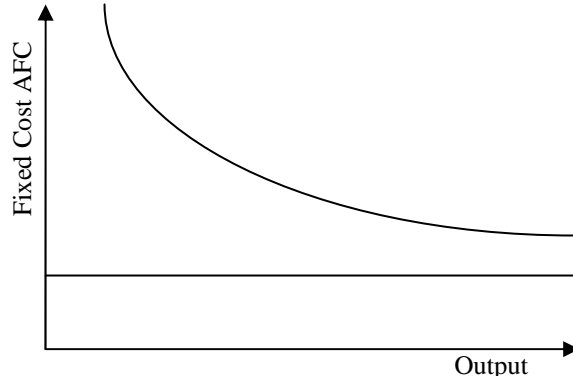

Figure-1: Falling Average Fixed Cost

$$pz(j) = \underbrace{ay(j) \times py(j)}_{\text{Basic Factor Cost}} + \underbrace{\sum_i ax(i,j) \times pq(i)}_{\text{Intermediate Input Cost}} + \underbrace{FC(j)/Z(j)}_{\text{Average Fixed Cost}} ; \qquad (1)$$

Above equation shows that average total cost is the sum of a) Unit basic factor cost b) Unit intermediate input cost and c) average fixed cost. Unit basic factor cost includes both labour and capital cost while capital cost excludes fixed cost.

Inclusion of Consumer's Preference for Varieties

Theoretically there are two important factors that could comprehensively represent consumers' preference for different varieties. They are A) Elasticity of substitution between varieties and B) Number of varieties. Their inclusion into our CGE framework is as follows.

Elasticity of Substitution

We considered an indirect measure of Elasticity of Substitution parameter in terms of price elasticity of demand faced by the firms. We borrowed our social welfare function from Krugman(1979) that takes price elasticities are different across industries as we find below:

$$W = \log\left(\sum_{i=1}^{N1} D_1^{\beta_1}\right)^{\frac{1}{\beta_1}} + \log\left(\sum_{i=1}^{N2} D_2^{\beta_2}\right)^{\frac{1}{\beta_2}} + \log\left(\sum_{i=1}^{N3} D_3^{\beta_3}\right)^{\frac{1}{\beta_3}} + \log\left(\sum_{i=1}^{N4} D_4^{\beta_4}\right)^{\frac{1}{\beta_4}} \qquad (2)$$

$\beta_i \equiv \left(1 - \dfrac{1}{\theta_i}\right)$ Here β_i is elasticity of substitution parameter for i[th] industry. N_i and D_i are the number of variety and domestic consumption of the ith product . W is social welfare.

Krugman(1979) also pointed out that social welfare function (2) has nice property that with large

N each firm will face demand elasticity = $\dfrac{1}{1-\beta_i} = \theta_i$.

When number of variety is large firms do not consider second term and so elasticity value

becomes θ_i . When all varieties are equally priced second term becomes $\dfrac{(1-\theta_i)}{N_i}$. As number of

variety is large second term vanishes. In our analysis price elasticity of demand for i[th] commodity is E_p

Here $E_P = \theta_i + \left(\dfrac{1-\theta_i}{N_i}\right)$ [9]. Now E_p value can be computed from our model and setting N=10[10],

we can compute θ_i which determines elasticity of substitution parameter in each sector. From our model we calculated price elasticity of demand for a) Primary sector b) Secondary sector c) Infrastructure and d) Other service sector as -0.35215,-.2642,-0.289,-0.3107 respectively[11].

5. Database and Calibration

For the calibration of our model parameters we used SAM of India for the year 2003-04 that we constructed in chapter-3 with four sectors, two basic factors and four types of households. For the estimate of fixed cost, we assumed 10% of the capital employed in the production process[12] is invariant to output in each year. It indicates that, as output increases by 10%, average capital cost will fall by 1%. For the social welfare function under imperfect competition, we have two determinants. First one is the number of product variety in different sectors and second one is elasticity of substitution between varieties corresponding to different sectors. For the first one we assumed, benchmark number of variety is 10[13]. For the substitution elasticity, we consider the relationship with elasticity of demand and using sectoral price elasticities computed from our model we calculated elasticity of substitution between varieties[14]. We have solved the model using GAMS package for benchmark equilibrium. SAM is regenerated during the process of calibration.

Table-2: SAM OF INDIA 2003-04(Rs. in Lakhs)

Sectors	Primary sector	Secondary sector	Infrastructure	Other service	Labour	Capital
Primary sector	7813229	35487406	2764682	148968	0	0
Secondary sector	6791879	72102447	15722644	6844878	0	0
Infrastructure	3310796	25253708	6639444	3069054	0	0
Other service	771827	13603244	8167558	8196396	0	0
Labour	34310321	33292466	24461809	38969523		
Capital	29878150	27090185	33397891	31081063		
RHH1	0	0	0	0	32279505	12834674
RHH2	0	0	0	0	29243484	29319601
UHH1	0	0	0	0	61509848	16734549
UHH2	0	0	0	0	8661430	5406382
PVT						9557281
PSE						4626200

GOV						3618000
Indirect taxes	-1306585	9471626	3514423	1145516		
Capital A/C	0	0	0	0		25363700
Rest of the world	12756258	28730550	3326565	4213424		

Table-3: SAM OF INDIA-2003-04(Continued)

Activities	RHH1	RHH2	UHH1	UHH2	PVT.	PSE	GOV	Ind. Taxes	Capital a/c	Rest of the world	Total
Primary sector	12294143	11910716	10703541	2211793	0	0	241670	0	1803896	2978019	93480335
Secondary Sector	12389764	15568374	14754899	818775	0	0	5157523	0	55622644	25376947	231376699
Infrastructure	5571019	5753069	6855314	1209437	0	0	1871435	0	3260561	10605075	100069843
Other service	13238946	17029747	25392996	5250963	0	0	24837174	0	693607	4824222	106094471
Labour	0	0	0	0						-312600	130721521
Capital	0	0	0	0						-1095200	120352089
RHH1	0	0	0	0	0	0	52075667	0	0	993035	53666294
RHH2	0	0	0	0	0	0	9824402	0	0	2157927	80904465
UHH1	0	0	0	0	0	0	9113270	0	0	6175802	93533470
UHH2	0	0	0	0	0	0	1190924	0	0	2562618	17821354
PVT									1216819		10774100
PSE	0	0	0	0							4626200
GOV	224068	3506373	1500237	2906519	6099400			24616465		-248200	40437165
Indirect taxes	1517569	2035126	13333662	440247			685090		5094808	-157127	24616465
Capital a/c	10308227	20323643	21205637	2945766	4674700	4626200	16661127			-3426241	67692335
Rest of the world	0	0	0	0							49026796
Total	53666294	80904465	93533470	17821354	10774100	4626200	40437165	24616465	67692335	49026796	

6. Simulation Experiments

We have made three simulation experiments related to trade liberalization a) 50% reduction of import tariff b) Technological up gradation and c) Greater foreign capital inflow. We changed the respective values of the parameters and solved the model to obtain counter factual equilibrium values. For comparative static changes, counter factual equilibrium values are compared with benchmark equilibrium values of the macroeconomic variables.

EXPERIMENT-1 Import liberalization in the presence of increasing returns to scale and "Consumers preference for variety".

We liberalized trade by 50% tariff reduction in the presence of increasing returns to scale in production sector and consumers preference for variety in the demand side and compared the result with trade liberalization under perfect competition. We find import increases by 5.62% as opposed to 6.81% increase of import in case of perfect competition. Exchange rate depreciates by 1.748% as opposed to 1.9 % in case of perfect competition. This led to reduced expansion of export by 4.94% as opposed to 5.9% in perfect competition. Reduced trade expansion is attributed due to the presence of 'excess capacity' in production that outweighs benefit from additional basis of comparative cost advantage namely "variety driven trade" apart from factor endowment difference and technology difference. GDP in this process increases by .097 as opposed to .296%

in perfect competition case due to the presence of 'excess capacity' in production process that outweighs benefit from increasing return to scale. Sectoral output increases in secondary sector, infrastructure and service sector where benefits of market imperfection like, increasing returns to scale and horizontal product differentiation owing to comer's preference for product variety could have been reaped due to the presence of 'excess unutilized capacity' in those sectors . On the contrary, agricultural output could not be expanded due to capacity constraints like, inadequate supply of arable land, lack of technology adoption possibility etc. Composite commodity price has been reduced with lower percentage than under perfect competition. Sectoral changes of import remains similar while sectoral changes of export have been lower than that of under perfect competition. Number of product variety and consumer's choice increases in all sectors excepting little reduction in infrastructural sector. Social welfare increases by .03% as compared to .146% in case of perfect competition. Even if consumers are gaining from increased product variety, there is some excess capacity loss in monopolistically competitive product market[15]. This causes welfare to increase by lesser percentage than in perfect competition case.

Under perfect competition long run equilibrium takes place at the minimum point of the long run average cost(LAC) curve and satisfies the condition P=AC=MR=MC while under monopolistic competition equilibrium takes place at the point of tangency of the demand curve to the LAC curve. At this point MC=MR and AC=P, but P> MC. As the consequence, equilibrium price is higher and output is lower under monopolistic competition than under perfect competition.

Under monopolistic competition too many firms in the industry and each are producing an output less than optimal at a cost which is higher than minimum. In the Figure-3

(Q_{IMP}-Q_{PER}) depicts excess capacity present in the industry under imperfect competition[16].

Above fact explains, starting from same benchmark scenario, lower increase of GDP, sectoral output, trade expansion and sectoral composite commodity price reduction under imperfect completion than under perfect competition in response to tariff reduction. In addition to, increased social welfare is lower under monopolistic competition than under perfect competition as equilibrium takes place in case of the former at an output below the socially optimal level.

EXPERIMENT-2

Technological progress in the presence of increasing returns to scale and "Consumers preference for variety".

We simulated the impact of 5% technological progress and compared the results with perfect competition. We find in most of the cases, imperfect competition results map with perfect competition results with little dissimilarities in magnitude. Under monopolistically competitive market structure with increasing returns to scale and consumer's preference for variety, a 5% technical progress leads to an expansion of GDP, gross investment, household consumption, sectoral export and import and sectoral real output roughly by 5%. As the case of perfect competition, composite commodity prices in the domestic market lowered down by more than 4.5% and domestic exchange rate is appreciated by 4.86%.Number of firms has been increased in almost all sectors.

Domestic policy towards skill formation and R&D promotion for ensuring technical progress may lead to growth of the economy in the long run. A continuous improvement of technology over time will increase output and gross investment that could expand existing capital stock in the next

period. With higher per capita capital stock economy could achieve sustainable development in the long run.
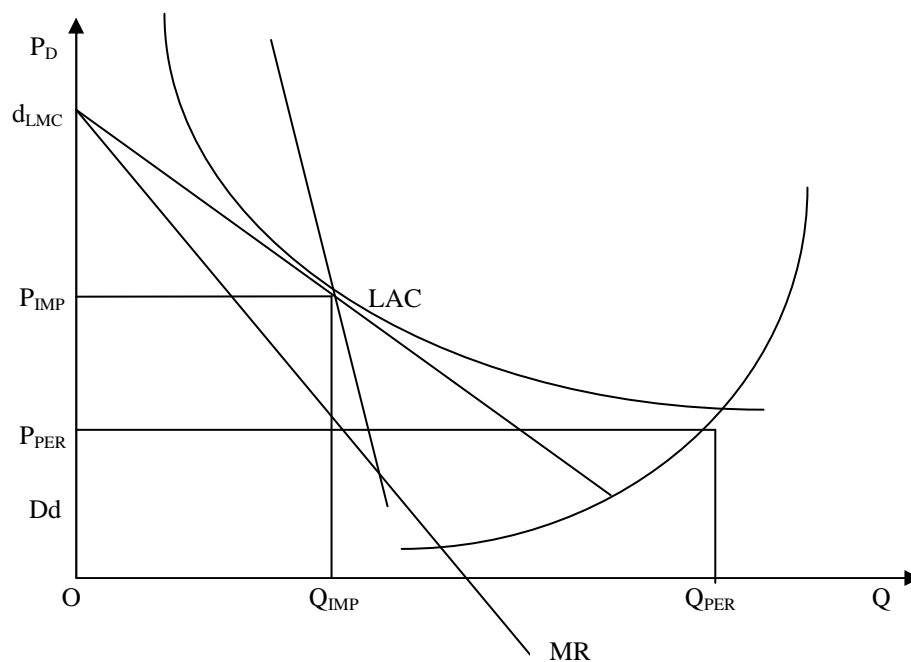
EXPERIMENT-3

Greater foreign capital inflow in the presence of increasing returns to scale and "Consumers preference for variety".
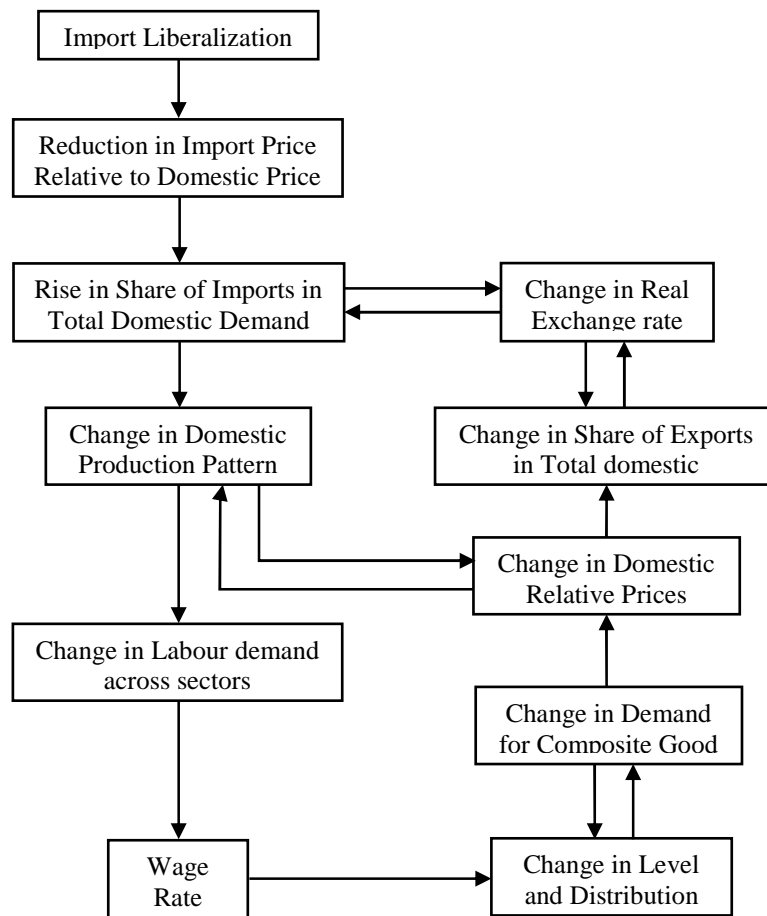
Figure-2: Major Interactions due to import liberalization

Figure-3
Price and output under Monopolistic Competition

International capital mobility and integration of global financial markets have been emerged as many developed countries removed capital controls after 1970s. Developing country like India too adopted liberalization policies towards greater inflow of foreign capital in order to augment domestic savings. As in the case of perfect competition we simulate a 25% increase of foreign capital under increasing returns to scale and consumers' preference for variety.

Under monopolistic competition also, foreign capital inflow appreciates exchange rate, increases imports and reduces export without much differences in magnitudes as compared to perfect competition case. Household consumption increases from increased real income as composite commodity prices are lowered down due to the competition among firms and higher capacity utilization. There is a small increase of number of firms in almost every sector.

7. Concluding Remarks

In this paper we studied trade policy consequences under market imperfection. In the present day globalized scenario emergence of scale economy, diverse consumer preference and market structure oriented industry behaviour give rise to the rethinking of international trade especially in the direction of intra industry trade .Our study reveals that under imperfect competition, reduction of import tariff follows standard trade theory results i.e. export and import expand, exchange rate

deteriorates, domestic sectoral output increases and composite commodity price falls. However, variety driven trade could not produce any greater domestic output, trade expansion (Higher volume of export and import) and gains from trade as compared to standard perfect competition case. This is probably because, increased gains from trade owing to the presence of third source of comparative cost advantage namely 'Variety driven trade' or gains from specialization is completely offset by excess capacity loss naturally present in imperfectly competitive market structures. Comprehensively, it could be stated that the presence of increasing returns to scale and imperfect competition although puts some insights into the basis of international trade; it could not alter standard trade theory results based on perfect competition.

Notes :

1. For an example, estimated long run gains from Canadian trade liberalization ranges 8-12% larger than gains suggested by conventional method, Cox, D. and Harris, R(1983).
2. In Indian context I/O table is published by Central Statistical Office (CSO) in every five tears gap. Saluja et al (2006) constructed SAM for India using I/O matrix for the year 1999.
3. Net indirect tax mentioned in the SAM has been classified into domestic indirect tax and import tariff.
4. In the Indian context government savings in most of the cases is negative that constitute large part of country's fiscal deficit. Expenditure of the government is usually determined in annual budget.
5. Market structure and foreign trade.
6. See Brander and Spencer (1985) and Brander and Krugman(1983) in this connection.
7. Purchase cost of them is called 'sunk' cost as the benefit from them may be accrued in the subsequent years. Gross domestic capital formation provides an addition to the stock of fixed capital like building, machinery, equipments etc.
8. This implies total industry fixed cost is constant and does not depend on entry or exit of new firms.
9. Considering each variety is equally priced.
10. We took same number of firms in each sector as 10. On an average competition among sellers lye within 10 varieties while consumer's preferences are usually confined within, on an average, 10 varieties of the same product.
11. We get few empirical support of our price elasticity computed value. In case of electricity in services[1] obtained value is -0.3, in case of bus transport[1] calculated value lies between -0.232 to -0.523.For the tobacco product price elasticity lies between -.4 to -.9.
12. This value can directly be obtained from SAM.
13. For the necessary underlying assumptions, consider immediately preceding section.
14. For more elaborate discussion, see the preceding section. Price elasticities are considered for a) Primary sector b) Secondary sector c) Infrastructure and d) Other service sector as -0.35215,-.2642,-0.289,-0.3107 respectively. We obtained these values from various economic literatures on Indian economy.
15. In the presence of fixed cost, equilibrium does not take place at the minimum point of LAC.
16. See E. Chamberlin, 'Monopolistic Competition Revisited 'Economic Journal (1952).

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APPENDICES

APPENDIX-1: MATHEMATICAL STRUCTURE OF THE BENCHMARK CGE MODEL

Production Block:

$$Y_j = b_j \cdot \left[\prod_h F_{h,j}^{\beta_{j,h}} \right] \tag{1}$$

$$X_{i,j} = ax_{i,j} \cdot Z_j \tag{2}$$

$$Y_j = ay_j \cdot Z_j \tag{3}$$

$$F_{h,j} = \beta_{h,j} \cdot py_j \cdot Y_j / pf_h \tag{4}$$

$$pz_j = ay_j \cdot py_j + \sum_i ax_{i,j} \cdot pq_i + \frac{FC_j}{Z_j} \tag{5}$$

Government behavior:

$$GINC = Td + Tdc + TInd + NCAT + ENT + TARR - Ts \tag{6}$$

$$Td = \sum_b taud_b \cdot \left[\sum_h pf_h \cdot FF_h \cdot r_{h,b} + GT_b + NCUT_b \right] \tag{7}$$

$$Tdc = tcorp \cdot (OPR + IND) \tag{8}$$

$$OPR = sop \cdot \left[\sum_h pf_h \cdot FF_h + NF_1 + NF_2 \right] \tag{9}$$

$$TInd = \sum_b tauz_j \cdot pz_j \cdot Z_j \tag{10}$$

$$TARR = \sum_i taum_i \cdot pm_i \cdot M_i \tag{11}$$

$$Ts = taus \cdot \sum_i pe_i \cdot E_i \tag{12}$$

$$Xg_i = mu \times GDP / pq_i \tag{13}$$

$$GT_b = gt_b \cdot GINC \tag{14}$$

$$GEXP = \sum_i Xg_i + \sum_b GT_b + Ts \tag{15}$$

$$S_G = GINC - GEXP \tag{16}$$

Investment behaviors:

$$Xv_i = lamda_i \cdot \left[Dep + \sum_b Sp_b + Sg + Sc + Sf \cdot epsilon \right] / pq_i \tag{17}$$

Savings:

$$HHIN_b = \sum_h \left[\sum_h FF_h \cdot pf_h + NF_1 + NF_2 \right] \cdot r_{hb} + NCUT_b + GT_b \tag{18}$$

$$HHIN_b = \left[\sum_h FF_h \cdot pf_h + NF_1 + NF_2 \right] \cdot r_b + NCUT_b + GT_b \tag{18.a}$$

Where $r_b = \sum_h r_{h,b}$

$$Sp_b = ssp_b \cdot HHIN_b \tag{19}$$

$$Sc = ssc \cdot (OPR + IND) \tag{20}$$

Household consumption:

$$Xp_{i,b} = alpha_{i,b} \cdot [HHIN_b - Td_b - Sp_b] / pq_i \tag{21}$$

International trade:

$$pm_i = epsilon * pWm_i * (1 + taum_i) \tag{22}$$

$$pe_i = epsilon * pWe_i * (1 + taus) \tag{23}$$

$$\sum_i pWe_i * E_i + Sf + \sum_b NCUT_b + NF_1 + NF_2 + NCAT + Ts = \sum_i pWm_i * M_i \tag{24}$$

Armington function:

$$Q_i = gamma_i \left[deltam_i \cdot M_i^{eta_i} + deltad_i \cdot D_i^{eta_i} \right]^{\frac{1}{eta_i}} \tag{25}$$

$$\frac{M_i}{Q_i} = \left[gamma_i^{eta_i} \cdot deltam_i \cdot \frac{pq_i}{pm_i} \right]^{\frac{1}{1-eta_i}} \tag{26}$$

$$\frac{D_i}{Q_i} = \left[gamma_i^{eta_i} \cdot deltad_i \cdot \frac{pq_i}{pd_i} \right]^{\frac{1}{1-eta_i}} \tag{27}$$

Transformation function:

$$Z_i = theta_i \cdot \left[xie_i \cdot E_i^{phi_i} + xid_i \cdot D_i^{phi_i} \right]^{\frac{1}{phi_i}} \tag{28}$$

$$\frac{E_i}{Z_i} = \left[theta_i^{phi_i} \cdot xie_i \cdot (1 + tind) \frac{pz_i}{\cdot pe_i} \right]^{\frac{1}{1-phi_i}} \tag{29}$$

$$\frac{D_i}{Z_i} = \left[theta_i^{phi_i} \cdot xid_i \cdot (1 + tind) \cdot \frac{pz_i}{pd_i} \right]^{\frac{1}{1-phi_i}} \tag{30}$$

Market clearing condition:

$$Q_i = \sum_b Xp_{i,b} + Xg_i + Xv_i + \sum_j X_{i,j} \tag{31}$$

$$FF_h = \sum_j F_{h,j} \tag{32}$$

Fictitious Objective function:

$$UU = \sum_b \prod_i Xp_{i,b}^{\alpha_{i,b}} \tag{33}$$

APPENDIX-1.A: LIST OF ENDOGENOUS VARIABLES

Y_j = Combined input used in j^{th} activity.

$F_{h,j}$ = Demand for basic input h in j^{th} activity.

Z_j = Output of jth activity

py_j = Price of combined input in j^{th} activity.

pf_h = Price of basic input h.

pq_i = Price of the ith commodity.

$GINC$ = Total Government income.

Td = Household income tax.

Tdc = Corporate tax.

$TInd$ = Indirect tax

pf_h = Factor price of the hth factor.

FF_h = Factor demand of the hth factor

GT_b = Government transfer to the bth household.

gt_b = Government income share transferred to bth household.

$Xp_{i,b}$ = b^{th} household consumption of the ith good.

Xg_i = Government consumption of the ith good.

$X_{i,j}$ = i^{th} sector's output goes to j^{th} sector as intermediate input.

Xv_i = i^{th} commodity used as investment good.

pq_i = Price of the ith commodity.

pe_i = Price of export.

Sg = Government savings.

Sp_b = Private savings of the bth household.

Sg = Government savings.

Sc = Corporate savings.

$epsilon$ = Exchange rate.

$HHIN_b$ = Income of the bth household.

pe_i = Export price of good i.in domestic currency.

pm_i = Imports price of good i in domestic currency.

pd_i = Price of domestic good.

pz_i = Supply price of the ith good.

pWe_i = World export price.

pWm_i = World import price.

$E_i =$ Export of good i. $M_i =$ Import of good i.

$epsilon =$ Exchange rate. $Q_i =$ Output composite good.

$D_i =$ Output domestic good. $UU =$ Social welfare function.

APPENDIX-1.B: LIST OF EXOGENOUS VARIABLES

$b_j =$ Production function shift parameter.

$\beta^{j,h} =$ Share of hth input within combined input in jth activity.

$ax_{i,j} =$ Per unit requirement of ith commodity in jth activity as intermediate input.

$ay_j =$ Per unit requirement of combined input in jth activity.

$r_{h,b} =$ h^{th} factor income share of bth household.

$ENT =$ Income of the government from entrepreneurial activity.

$taud_b =$ Share of total household income paid as income tax by bth household.

$mu_i =$ Share of government expenditure on i^{th} commodity.

$NCAT =$ Net transfer to government.

$Sf =$ Foreign savings at world prices.

$lamda_i =$ Proportion of savings converted into investment.

$Dep =$ Depreciation of capital.

$FF_h =$ Total factor demand of the hth factor.

$gamma_i =$ Scale parameter in Armington function.

$deltad_i =$ Share coefficient of domestic good in Armington function.

$deltam_i =$ Share coefficient of import good in Armington function.

$eta_i =$ Constant determining elasticity of substitution in Armington function.

$theta_i =$ Scale parameter transformation function.

$xie_i =$ Share parameter of export in Transformation function.

$xid_i =$ Share parameter of domestic good in transformation function.

$phi_i =$ Constant determining elasticity of substitution in Transformation function.

$tind =$ Indirect tax rate. $taum_i =$ Import tariff rate.

$taus =$ Export subsidy rate.

$NCUT_b =$ Net current transfer to b^{th} household.

$tcorp =$ Share of corporate income to tax.

OPR = Operating profit. IND = Interest on debt.

sop = Share of operating profit to total factor income.

NF_1 = Net labor income earned abroad. NF_2 = Net capital income earned abroad.

$Tpurhh$ = b^{th} household purchase tax. $Tpurg$ = Government purchase tax.

$Ting$ = Taxes on intermediate. $Tinv$ = Taxes on investment good.

Ts = Taxes on export.

$tpurhh_b$ = Share of household purchase paid as purchase tax by b^{th} household.

$tpurg$ = Share of government purchase paid as purchase tax.

$ting$ = Share of intermediate good purchase to tax.

$tinv$ = Share of investment to tax. $taus$ = Share of export paid as tax.

. FC_j = Fixed cost in the jth sector.

APPENDIX-2: SIMULATION BASED ON IMPERFECTLY COMPETITIVE CGE

Table-4 : Simulation Experiment Results

Economic Variable	Base run	Exp-1		Exp-2		Exp-3	
Macro Indicators	In Rs. Lakhs	Imperfect Competition	Perfect Comp.	Imp. Comp.	Perfect Comp.	Imp. Comp.	Perfect Comp.
GDP	4.75E+08	0.097	0.332	5.033	5.056	0.056	0.033
Gross investment	67692335	0.547	0.642	5.35	6.02	1.6	1.77
Gross consumption	462304387	-0.028	0.123	5.82	5.69	0.027	0.139
Welfare	3061.817[1]	0.03	0.256	0.193	5.7	0.002	0.143
External Account							
Import	4.97E+07	5.62	9.24	5.39	5.53	1.324	1.4
Export	45206080	4.94	7.99	4.77	4.78	-0.92	-1.049
Exchange rate	1	1.748	2.623	-4.86	-4.88	-0.524	-0.556
Government Account							
Govt. Income	23776038	-10	-13.4	0.151	0.138	0.17	0.26
Govt. Expenditure	40437165	-4.1	-5.377	0.061	0.054	0.067	0.101
Govt. savings	-16661127	-0.007	-0.093	-9.46E-04	1.45E-04	-0.006	-0.004
HH Consumption							
RHH1	40413419	0.123	0.279	5.86	5.01	0.019	0.028
RHH2	5.44E+07	-0.3	-0.417	5.76	5.2	0.042	0.038
UHH1	3.58E+08	0.09	0.306	5.85	6.45	0.021	0.26
UHH2	9490968	0.8	0.143	5.74	5.011	0.024	0.012
Sectoral output							
Primary sector	7.85E+07	-2.5	-1.8	4.956	5.33	0.114	-0.013
Secondary sector	1.91E+08	0.345	1.189	4.9	5.2	0.33	0.144

Infrastructural services	9.86E+07	0.343	1.23	5.5	5.07	-0.091	-0.078
Other Services	8.47E+07	0.099	-0.078	2.9	4.622	-0.07	-0.027
Composite prices							
Primary sector	1	-1.523	-1.92	-4.7	-4.761	-0.082	-0.047
Secondary sector	1	-1.41	-2.08	-4.7	-4.76	-0.084	-0.025
Infrastructural services	1	-0.74	-0.88	-4.6	-4.74	0.006	0.051
Other Services	1	-0.39	-0.448	-4.57	-4.752	-0.012	0.011
Sectoral Import							
Primary sector	1.28E+07	19.8	19.917	5.33	5.655	1.161	1.17
Secondary sector	2.87E+07	3.38	3.101	5.33	5.568	1.454	1.5
Infrastructural services	3.33E+06	4.464	4.26	6	5.46	1.132	1.34
Other Services	4.21E+06	5.33	4.54	3.58	4.95	1.064	1.24
Sectoral Export							
Primary sector	2978019	1.169	2.955	4.59	5.04	-0.868	-1.1
Secondary sector	25376947	5.81	7.073	4.53	4.91	-0.613	-0.94
Infrastructural services	10605075	4.73	5.838	5.14	4.78	-1.08	-1.179
Other Services	4824222	3.98	4.154	2.28	4.32	-1.09	-1.131
Number of firms							
Primary sector	10	1.23	----	5	----	0.079	---
Secondary sector	10	1.12	----	4.99	----	0.082	---
Infrastructural services	10	-0.175	----	-0.75	----	-0.033	---
Other sector	10	0.09	----	4.85	-----	0.009	---

Source: Author's simulation

[1] Welfare function is taken in log linier form. In case of perfect competition base run welfare is 5.10E+07.E stands for shifting decimal place in the right side.