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Firm's behavior in the presence of antidumping laws

Khan, Nadeem, Ph.D.

Iowa State University, 1994

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Ann Arbor, MI 48106

Firm's behavior in the presence of antidumping laws

by

Nadeem Khan

A Dissertation Submitted to the

Graduate Faculty in Partial Fulfillment of the

Requirements for the Degree of

DOCTOR OF PHILOSOPHY

Department: Economics
Major: Economics

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In Charge of Major Work

For the Major Department

For the Graduate College

Iowa State University
Ames, Iowa

1994

DEDICATION

I dedicate this work to my family who supported me at each step of my life.

TABLE OF CONTENTS

CHAPTER I

INTRODUCTION

Since World War II there has been a significant trend all over the world for the general levels of trade barriers to fall. Conscious efforts, through international negotiations, have been made since then at all levels to promote freer international trade.

This movement for bringing down all types of visible and invisible trade barriers, which was spearheaded by the United States of America, was the result of the general desire of all the world nations at the end of the war not to repeat the retaliatory trade policies pursued during the 1930's and to avoid depressions many believe were caused, or exacerbated, by these policies.

However, with the expansion of trade over the past years, commercial disputes have also arisen. These disputes are typically concerned with specific commodities and, in some cases, have led to the imposition of new barriers to replace those that have been removed. These trade disputes, thereby, have prompted the lawmakers in different countries to modify their trade laws or the administration of these laws to handle the changing circumstances. Dumping is one among such trade dispute and is one of the moot points in all international trade negotiations.

Dumping[1] is defined as selling a product in a foreign country at a price that is lower than the price charged by the same firm in its home market or at a price below costs of production. Sales of this type are defined in the U.S. law as sales at less than fair value.

Almost all industrialized nations of the world now have laws against dumping which can penalize a foreign exporter who is found to have dumped its products in the importing

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[1]For an elaborate definition of dumping, see chapter II.

country. According to the United States antidumping laws, under certain conditions a special tariff may be imposed on foreign goods sold in the United States and priced at less than fair value. To have the special tariff imposed, it is necessary to show that dumping has caused or has threatened to cause material injury[2] to the domestic industry.

Ironically, on the one hand there have been worldwide efforts to bring down trade barriers, and ,on the other hand all types of invisible trade barriers such as antidumping and countervailing duties are being invented. Antidumping laws have also proven to be one type of invisible trade barrier. Most nations, as mentioned earlier, have laws against dumping because this type of protection is allowed even under the GATT rules. For this reason the number of antidumping cases processed each year are on the rise (see Table 1 and 2).

In the U.S. antidumping cases begin with a complaint filed simultaneously with the Department of Commerce and the International Trade Commission. The complaint could come from anyone, including the U.S. Secretary of Commerce; however, complaints are generally made by groups such as firms, trade unions, or industry associations which closely tied to the production of the good competing with the allegedly dumped merchandise. Included in the complaint are evidence that dumping may be occurring and data designed to illustrate injury or threat of injury.

The International Trade Commission is an independent, quasi-judicial agency, headed by five commissioners, appointed by the president of the U.S., and staffed by economists and lawyers. The International Trade Commission investigates various trade-related issues and provides advice, based on its investigations, to the executive branch of the U.S. government. Its job with respect to antidumping cases is to investigate

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[2]There is no comprehensive definition of material injury.

Table 1. Industrial Countries: Antidumping Investigations and Actions. 1981-'87

Countries	1981 Investi gations	Action	1982 Investi gations	Action	1983 Investi gations	Action	1984 Investi gations	Action	1985 Investi gations	Action	1986 Investi gations	Action	1987 Investi gations	Action
Australia	49	28	77	47	80	58	56	36	63	30	63	10	11	
Industrial Countries	34	14	55	25	59	44	30	26	38	15	35	7	8	
Developing Countries	15	11	20	20	21	13	21	10	19	12	20	3	3	
Centrally Planned Econs.	--	3	2	2	--	1	5	--	6	3	8			
Canada	23	13	72	21	36	41	31	16	36	27	55	45	34	36
Industrial Countries	12	8	54	10	27	29	20	9	18	16	21	18	21	20
Developing Countries	8	1	15	7	7	10	8	5	12	8	30	17	IU	12
Centrally Planned Econs.	3	4	3	4	2	2	3	2	6	3	4	10	3	4
European Community	47	16	55	42	36	45	48	31	45	12	37	21	10	8
Industrial Countries	9	18	18	9	11	12	16	9	9	9	11	9	2	3
Developing Countries	3	5	15	4	9	12	5	6	16	1	8	--	4	1
Centrally Planned Econs.	35	3	22	29	16	21	27	16	20	2	8	12	4	4
United States	14	4	61	45	47	15	71	25	65	53	70	50	47	43
Industrial Countries	7	3	47	41	27	9	32	8	19	19	30	15	32	25
Developing Countries	4	--	13	3	19	6	23	17	41	20	34	32	13	10
Centrally Planned Econs.	3	1	1	1	1	--	16	--	5	14	6	3	2	8

3

Table 1 (Contd.)

Total	133	61	265	155	199	159	206	108	209	122	225	126	102	87
Industrial Countries	62	33	174	85	124	94	98	52	84	59	97	49	63	48
Developing Countries	30	17	63	34	56	41	57	38	88	41	92	52	30	23
Centrally Planned Econs.	41	17	28	36	19	24	51	18	37	22	26	25	9	16

This table is taken from International Monetary Fund's Occasional Paper 63 (1988) "Issues and Developments in International Trade Policy".

Sources: Finger and Olechowski (1987); General Agreement on Tariffs and Trade, "Semi-Annual Reports Under Article 14:4 of the Agreement" (Geneva), various issues. Based on GATT classifications (see Appendix III)

The countries listed have initiated virtually all the antidumping investigations undertaken worldwide. Actions taken include the imposition of definitive duties and minimum price undertakings by exporting countries. Investigations include those opened in the context of reviewing an existing antidumping duty or after allegations of breach of an undertaking. The based on actidata are ons reported by signatories to the GATT Committee on Antidumping Practices, which exclude the actions taken against non signatories.

4

Table 2. United States Antidumping Cases 1980-1988
By Country and Outcome
(number of cases)

Country VER	Restrictive Other	Restrictive Total	Not Restrictive		Total All Cases
Australia	1	0	1	1	2
Austria	4	0	4	1	5
Canada	6	8	14	7	21
European Community:	66	20	86	41	127
Belgium	7	2	9	1	10
France	9	4	13	7	20
Germany, F.R.	12	3	14	10	25
Greece	0	0	0	1	1
Italy	6	7	13	10	23
Luxemburg	6	0	6	0	6
Netherlands	5	1	6	3	9
Portugal	1	1	2	0	2
Spain	10	1	11	4	15
United Kingdom	10	1	11	5	16
Finland	4	0	4	0	4
Japan	13	19	32	12	44
New Zealand	0	1	1	1	2
Norway	0	0	0	1	1
South Africa	5	1	6	0	6
Sweden	0	4	4	0	4
Switzerland	0	0	0	4	4
Eastern European Countries:	23	7	30	3	33
Czechoslovakia	2	0	2	0	2
Germany, D.R.	4	2	6	1	7
Hungary	2	1	3	1	4
Poland	6	0	6	0	6
Romania	6	2	8	0	8
USSR	0	1	1	1	2
Yugoslavia	3	1	4	0	4

Table 2 (Cont'd)

Developing Countries:	53	44	97	35	132
Argentina	0	2	2	3	5
Brazil	14	2	16	5	21
Chile	0	2	2	0	2
China	3	9	12	3	15
Columbia	0	1	1	3	4
Costa Rica	0	1	1	0	1
Ecuador	0	1	1	0	1
El Salvador	0	0	0	1	1
Hong Kong	0	1	1	0	1
India	0	2	2	1	3
Iran	0	1	1	0	1
Israel	0	2	2	1	3
Kenya	0	1	1	0	1
Korea	14	3	17	5	22
Mexico	3	2	5	1	6
Peru	0	0	0	1	1
Philippines	0	1	1	0	1
Singapore	0	2	2	2	4
Taiwan	9	5	14	8	22
Thailand	0	3	3	0	3
Turkey	0	2	2	0	2
Venezuela	10	1	11	1	12
Totals					
All Countries	175	104	279	106	385
Developed Countries	99	53	152	68	220
Developing Countries	53	44	97	35	132
Eastern European Countries	23	7	30	3	33

Source: Finger and Murray (1990)

the question of injury. According to Husted and Melvin (1993), "the International Trade Commission collects data on various aspects of the domestic industry and on the prices and quantities of imports. What it looks for is evidence of a link between imports and certain industry characteristics that would suggest that imports of the dumped merchandise have been to blame for the state of the industry. These industry characteristics include losses in the following: sales, market share, profits, productivity, return on investment, and capacity utilization. The International Trade Commission also considers effects on employment, inventories, wages, and the ability to raise new capital. Once the data have been collected and analyzed, the six commissioners vote on the question of injury".

While the International Trade Commission investigates injury, the Department of Commerce investigates whether dumping has actually occurred. The Department of Commerce has 160 days to make a preliminary assessment of the question, including a first guess as to the size of the dumping margin. If the Department of Commerce finds that there is evidence that dumping might exist, all imports of the product in question are immediately subject to an increased tariff equal to the estimated dumping margin. The Department of Commerce then begins a further investigation of whether dumping has occurred and at the completion of the investigation makes a final ruling. If, after further study, the Department of Commerce finds that dumping has not occurred, then the special duties that had been previously imposed are rebated. Otherwise, the process continues until the International Trade Commission makes its final ruling as to the extent of injury.

If the International Trade Commission rules in its final report that injury has not occurred, then again the case is terminated and the special duties are rebated. If both the Department of Commerce and the International Trade Commission rule in favor of the

petition, a permanent tariff[3] is put in place, equal to the dumping margin calculated by the Department of Commerce in its final investigation.

There is a general impression that due to the political pressure efforts are made by the officials to find judgment in favor of the domestic complainant. Handley (1988,89) mentions situations where the EC investigation procedure appears to be biased in terms of finding dumping. According to Destler (1986), in the U.S. the Congress has sought to increase the rate at which the judgments are awarded in the antidumping cases. In 1980, under the pressure of the Congress, the responsibility of investigating the size of dumping margin was transferred from the Treasury Department to the Department of Commerce. It was felt that as the chief advocate of business in the U.S., the Department of Commerce would be more aggressive in deciding dumping cases than the Treasury Department. The Department of Commerce was also advised to make greater use of constructed values rather than foreign prices in calculating fair value, presumably because the use of constructed value makes it more likely that dumping will be found.

It would be safe to suggest that the use and abuse of the antidumping laws is rather frequent these days and more and more domestic producers are seeking shelter under these laws. This distorts the behavior of the exporting firms as well as the competing firms in the importing country in such a way that while the antidumping laws impose constraints on the foreign exporting firms, they give an edge to the domestic firm over its foreign rival.

My objective, in the proceeding chapters, is to analyze the distorting effect of antidumping laws, i.e., how the presence of antidumping affects the behavior of firms in a simple duopoly setting.

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[3]Although the exporting firm has a right to appeal, there is no statutory time limit after which the Department of Commerece is supposed to revise the case.

CHAPTER II

LITERATURE REVIEW

Unfair trade practices are one of the main issues in the multilateral (e.g. GATT), as well as the bilateral trade negotiations these days and dumping is a highly prominent issue in these talks. The term dumping, as used in the theory of international trade, is very controversial and it is subject to many different interpretations.

The United States antidumping law defines dumping as a situation in which an importer's "fair value" exceeds the purchase price paid by the importer or exporter's sale price [1].

The 1967 GATT Antidumping Code, which is an elaboration of Article VI of the General Agreement, defines dumping as the selling of products at prices that are "less than the normal value of the products" [2]. A price is considered to be less than its normal value if the former is less than the price of the same product in the exporting country or, in the absence of such a domestic price, is less than either the highest price of the

[1]The present antidumping law is contained in title VII of the Tariff Act of 1930, which was enacted in the Trade Agreement At of 1979. The 1979 provisions superceded the Antidumping Act of 1921.
[2]Article VI of the General Agreement on Tariff and Trade entitled "Antidumping and Countervailing Duties" reads at paragraph 1 :
1.   The contracting parties recognize that dumping, by which the products of one country are introduced into the commerce of another country at less than the normal value of the products, is to be condemned if it causes or threatens material injury to an established industry in the territory of a Contracting Party or materially retards the establishment of a domestic industry. For the purpose of this Article, a product is to be considered as being introduced into the commerce of an exporting country at less than its normal value, if the price of the product exported from one country to another
        (a) is less than the comparable price, in the ordinary course of trade, for the like product when destined for consumption in the exporting country, or,
        (b) in the absence of such a domestic price, is less than either
(i) the highest comparable price for the like product for export to any third country in the ordinary course of trade, or
(ii) the cost of production in the country of origin plus a reasonable addition for selling cost and profit.
        Due allowance shall be made in each case for differencees in conditions and terms of sale, for differences in taxation, and for other differences affecting price comparability.

comparable product in a third country or the cost of production in the exporting country plus a reasonable markup.

From an economist's point of view, dumping occurs when a firm sells below its marginal cost and not necessarily below average total cost because from standard textbook models we know that selling at a price below average total cost can be optimal for a competitive profit-maximizing firm if there are fixed costs. While spatial price discrimination is sufficient, it is not a necessary condition for dumping to occur. For example, a product is considered dumped even though the domestic price is lower than the export price, when they both are below cost. In this literature it is referred to as cost dumping. In circumstances where sales are made below the cost of production and the domestic market of the exporting country is small enough to be ignored, or when exports originate from a non market economy, investigation of antidumping cases under the US. Trade Act requires "constructed value" methodology to determine dumping. Constructed value is defined as the cost of materials and processing plus a minimum of eight to ten percent margin for overhead and profits. Early antidumping laws were often defined on the basis of price discrimination, but later statutes have largely been in terms of "fair market price".

Almost all the literature dealing with dumping in international trade is based on models of imperfect competition. This literature almost exclusively focuses on the positive analysis of dumping, i.e., why would a profit maximizing firm sell below its cost? The literature dealing with the subject of dumping can be broadly classified into two categories on the basis of the time context of the models: Static or one-period models, or dynamic or multi-period models.

Static Models

The main theme of the results of the static/one-period models in the absence of any uncertainty, may be summarized as follows: it may be optimal for a profit maximizing firm to deliberately dump if :

a. markets are segmented, i.e., if the dumped good cannot be sold back in the exporting country; otherwise the price difference cannot be maintained.

b. exporting firm must have some market power in at least one of the markets.

c. elasticity of demand in domestic and foreign markets are different, in particular demand elasticity in the export market must be higher than that at home.

The "classic theory" of dumping was laid down by Viner (1923); Robinson (1933) described it as a discriminating monopolist's behavior. The Viner/Robinson explanation of dumping behavior is a simple application of the micro economic theory of price discrimination where a firm has no competition in two markets. If there is no market segmentation, the firm cannot discriminate against buyers in one market. Its optimal strategy then is to set a price for both markets at a level that maximizes its profits. Viner and Robinson demonstrate that if markets are segmented and price elasticities of demand are different in the two markets, then a firm can increase its profit above simple monopoly profits by setting different prices in the two markets. If the demand is more elastic in the export market, then profit maximizing behavior leads to dumping.

Eichenegreen (1982) provides several plausible explanations as to why the elasticity of demand may differ across markets and may be higher in the export market. For example, there may be a competitive fringe in one country, but not in another.

More recently, Brander and Krugman (1983) and Dixit (1988) have extended this idea to the cases of oligopoly or monopolistic competition. In these instances, firms must consider not only market demand elasticity but also the share of the market that it will be able to capture. The profit maximizing decisions are similar, but the marginal revenue is replaced with the perceived margin revenue. In these cases firms should also incorporate some notion of how competing firms respond to each others actions.

Brander and Krugman (1983) developed a two- country duopoly model where each firm holds a Cournot type conjecture about the other firm's response to its own actions, i.e., the firm in each country assumes that the firm in the other country will not change its output in response to a change in output of the former. The market-segmentation assumption remains very important so that each firm can choose profit maximizing output for each country separately. In this paper the rational for dumping comes from the fact that transportation costs cause the cost of producing and selling abroad to be higher than in the domestic market.

The profit function of home (H) and foreign (F) firms are Π and $\overset{\bullet}{\Pi}$, respectively.

$$\Pi = XP(Z) + \overset{*}{X} \overset{*}{P}(\overset{*}{Z}) - C(X + \overset{*}{X} \big/ g) - \Phi$$

$$\overset{*}{\Pi} = YP(Z) + \overset{*}{Y} \overset{*}{P}(\overset{*}{Z}) - C(Y/g + \overset{*}{Y}) - \overset{*}{\Phi}$$

where Z ($\overset{*}{q}$) is the total amount of identical product that both firms produce and which is sold in the home (foreign) country. The variables with asterisks are associated with country F, e.g., $\overset{\bullet}{X}$ is the country H's output sold in the country F and $\overset{\bullet}{Y}$ is the country F's

output sold in country F. And similarly X is country H's output sold in country H and Y is country F's output sold in country H. Brander and Krugman call the transportation cost, c/g, an "iceberg" or spoilage type where $g \le 1$. Φ and $\overset{*}{\Phi}$ in the above profit functions are fixed costs in country H and country F, respectively. Since symmetric conditions are assumed, it is sufficient to analyze one country. C is a scalar, i.e., $C'(.) = C$ and $C'' = 0$. The first order conditions for profit maximization in the country H for both firms give the reaction functions of the following type:

$$\Pi_X = X.P' + P - C = 0$$

$$\overset{*}{\Pi}_Y = Y.P' + P - C/g = 0$$

When written in terms of demand elasticity $\varepsilon = -P/Z.P'$ and $(\sigma = Y/Z)$ F's share in H's market, the following reaction functions are obtained

$$P = \frac{c.\varepsilon}{(\varepsilon + \sigma - 1)}$$

$$P = \frac{c.\varepsilon}{g(\varepsilon - \sigma)}$$

The above equations can be explicitly solved for P and σ, under certain very plausible conditions. The solution to the above problem yields:

    a. in equilibrium, each firm has a positive share in the export market

    b. the markup on the export sales is always lower than that in the domestic market for each firm in equilibrium. These results are obtained due to the presence of

transportation costs and symmetry the authors have assumed which implies same price in both countries.

Here Brander & Krugman use a different definition of dumping, which is having a higher markup in the domestic market than in the export market, i.e., adjusted for transportation costs.

In a Cournot equilibrium, firms in each country dump in the market abroad. The duopoly rivalry of the firms causes intra- industry trade to take place and the presence of transportation cost forces each firm to earn a smaller mark up over its cost in the export market than at home. This is what the authors call reciprocal dumping.

Dixit (1988) focuses not on the reasons for dumping, instead, his primary concerns are the implications of government policies in response to a foreign subsidy or dumping. The question he addresses is whether the foreign subsidy or dumping should be countervailed and if so, is there a distinction between optimal response to foreign dumping and subsidization? With the help of a conjectural variation model of oligopoly between domestic and foreign firms, selling only in the domestic market, he finds justification for partially countervailing the foreign subsidy but no rationale for countervailing dumping.

Using linear demand functions, Dixit analyzes the cases of close substitutes and homogeneous goods; and in both cases, the results are qualitatively identical. The full optimal policy[3] always calls for partial countervailing duties when the foreign government subsidizes production of its exporting firm, but lowering of tariff when foreign firms engage in aggressive competition or dumping that decrease domestic price.

These results hold even if only one of either tariff or subsidy is available to the government as a policy instrument. The question that arises here is that if the foreign

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[3]The optimal policy is defined as the policy which maximizes the importing country's welfare when its government can use subsidy or tariff, or both together as policy instruments.

government knows the domestic government policy rule, then why would the foreign government subsidize its exporting firm when the subsidy is going to be extracted by the importing country through a countervailing tariff? There are more plausible ways for the foreign government to try to support its exporting firms through some other methods not easily detectable by the importing country, e.g. through tax codes. The foreign government can disguise the subsidy in the form of a lump sum transfer to its exporting firm, not affecting the marginal cost of the firm. This would provide the exporting firm a cushion against any potential loss or bankruptcy if it sells its products below costs in the importing country.

Such government transfers or guarantees by the government of some minimum profits, in case of bankruptcy threat, can significantly alter the optimal capital structure of the firms. This may enable a firm to be more flexible in its pricing or more aggressive in marketing its product in the export market. In Dixit's framework, this will only lower the value of the conjectural variation parameter and, thus, there will be no justification for the importing country's policy makers to countervail the predatory actions of the exporting firms.

In a world without uncertainty, dumping is always deliberate. Once uncertainty is introduced into the trading environments, dumping may be unintentional and the conditions mentioned earlier may no longer remain necessary for dumping to occur. Thus, market power is not a necessary condition, as it is quite possible for an exporter to act as a price taker at home and abroad, and yet sales may take place at different prices in different markets after the resolution of uncertainty. Simple exchange rate uncertainty can also produce this result. Krugman (1989) discusses cases in a different context where

firms keep the prices in the foreign market unchanged while their costs increase due to appreciation of home currency. This issue will be discussed in the next section.

If a firm has some market-power, different elasticities are not necessary for dumping to occur. Again, some source of randomness at the time the export decisions are made can generate dumping ex-post. Blair & Cheng (1989) demonstrate that both marginal attitude towards risk and demand uncertainty abroad may cause a price setting firm to choose a price in the foreign market that is below than that in the home market even if price elasticities of demand in both markets are identical.

Davis and McGuinness (1982) also show that selling below marginal cost can occur because of uncertain demand. They argue that dumping can also occur when a firm tries to maximize sales subject to a profit-constraint or engages in a strategic behavior to deter entry into a market. In Devis and McGuinness model the producer has monopoly power in one of the markets. Almost all the models discussed earlier assume constant marginal cost for the analysis, the exceptions are Davies and McGuinness who use U-shaped, and L-shaped cost curves. They show that in the presence of price uncertainty in the export market, pursuance of some managerial goals can lead a profit-maximizing firm to charge a price at home that is higher than that in the export market.

Thus, even with the introduction of uncertainty in the models, market segmentation is still required for price differences to occur, though market structure and firms' strategy may then not be necessary as a determinant of dumping.

Multiperiod Models

As noted earlier, selling below average total cost can also constitute dumping, and it is not strictly necessary that export market prices be below domestic prices. The issue

of market-power and different price elasticities become irrelevant, as does the need for market segmentation. The cost dumping case is important in practice, because most exporters produce exclusively or predominantly for export. Often it may be in a firm's interest to sell below variable or even marginal cost for some time. Accepting losses in the short run may become a requirement for establishing bigger market share or to enable the firm to move down its learning curve, thereby increasing expected long run profits. Some multi-period dumping models find that it is rational for a firm to initially sell below its marginal cost if costs of production in the later periods are inversely related to the quantity produced in the earlier periods. This is called "learning by doing" in the literature.

Gruensprecht (1988) highlights the importance of inter temporal linkages through the cost structure. With the help of a two-period duopoly model, where the two firms are located in two distant countries and produce a homogeneous product, Gruensprecht shows that when future costs are linked to current output levels, through either experience effect or adjustment costs, it may be optimal for an unconstrained firm to sell below current marginal cost.

Ethier (1982) and Eichenegreen and Van der Ven (1984) find that a profit maximizing firm will set price below cost on an intermittent basis. In Eichenegreen and Van der Ven's (1984) model, firms choose to sell below cost on a cyclical basis to replenish their customer base. They demonstrate that the existence of cost of adjustment associated with changes in output level may cause firms to sell below cost.

Ethier (1982) explores the motivation of a profit maximizing firm to set prices below its cost on cyclical basis. He found that it is optimal for a firm to dump in the periods when the economy is on a down swing. In his adjustment cost model, a

homogeneous good (steel) is produced in both the United States and Japan using two factors of production. One factor, managers, is never laid off while the other (labor) may be laid off. Perhaps due to different social rules of layoffs, the adjustment cost, as reflected by the manager to labor ratio, is higher in Japan than that in the US. Both wages and security of employment enter workers' utility functions. Since employers offering secure jobs can pay lower wages and wages are fixed across the two states of the economy, therefore, it can be profit maximizing to retain factors of production in an economic downturn, even if the marginal product of a factor falls below the wage rate. The firm makes profits in the upturns and incurs losses in the downturns, assuming output is not storable. In this case, firms offering secure jobs may choose to sell below variable cost in cyclical downturns. Thus, Ethier shows that in the United States layoffs occur during the bad state of the economy, whereas in Japan workers are not laid off during similar periods and consequently produce more than their home market can absorb. To unload this over production, the Japanese firms dump in the United States at prices below their costs.

Thus, Ethier shows that cost dumping is not irrational when factor market rigidities or transaction cost and output price uncertainty force a firm to choose a scale of production before it knows the market price. In such circumstances, a firm may have to sell the excess output at a price below cost.

In an attempt to explain the observed stickiness of prices of traded goods in an export market in the face of exchange rate movements, Krugman (1989) demonstrates that sometimes it may be justified to sell below cost in an export market. Referring to the studies by Mann (1987) and Hooper and Mann (1987), Krugman shows that the margins

on certain imported goods in the importing country are significantly less than their counterparts in the exporting countries.

In another example that compares Japanese unit labor cost with its manufactures export prices, both measured in U.S. dollars, Krugman shows that Japanese manufacturers have tried to stabilize their prices in export markets rather than allowing them to move in line with their costs. He also cites the example of the price of a Volvo car, imported from Sweden, where unit labor cost , measured in U.S. dollars, rose by 70 per cent during 1985-1987 while its price rose by only 17 percent during the same period. This demonstrates an unwillingness to alter export price when the exchange rate changes.

Krugman (1989) presents one possible explanation of this phenomenon in terms of the *"sunk cost model"*. The basic idea of the sunk cost model is that in the face of severe competition in the world market a firm that wants to export must invest substantial resources in adopting its product to the foreign market and develop a marketing and distribution network. These costs of entering a foreign market may be regarded as *sunk* once they have been incurred, i.e., a firm can not easily sell off its visible or invisible assets and recover the investment. Once these costs are incurred, a firm that has static expectations will be willing to stay in the market if it can only cover its variable costs due to exchange rate movements. So Krugman (1989) says, there is a "range of no change" for each firm, a range of exchange rate movement over which a firm will continue exporting if it is already doing so but will not be induced to begin exporting if it did not start out in that position.

In another explanation, Krugman (1989) says, in reality firms do not have static expectations. He stresses that a firm's plans are based on expected exchange rates that lag the actual. Firms will not enter a market as soon as the returns at the current exchange

rate exceed the annualized value of sunk costs if they believe that the current favorable exchange rate is temporary; they will not exit a market , even when they can not cover variable costs, "if they view themselves as hanging onto a position that will in the not-too-short future be profitable once again".

Anderson's work (1990) also falls into the category of multiperiod analysis of dumping. He provides an inter-temporal linkage through sales in two periods. He shows that a perfectly competitive firm which maximizes profits over more than one period may have an incentive to sell below its marginal cost in an export market if there is a reasonable probability that this market is going to be constrained in the future. This incentive is provided by the Voluntary Export Restraint (VER) allocation rule used by the importing country, which ties the assignment of the VER quotas to the previous sales or share of the market.

If there is a positive probability of a future VER, a perfectly competitive exporting firm has an incentive to dump in the current period in order to increase its sale or market share in the export market, thereby increasing its likelihood of getting an export license or a bigger quota under a VER. Anderson (1990) describes this as "current sales below cost buys options in the form of rights to license, with dumping acting like arbitrage to ensure that the value of the option equals its cost, the dumping margin". So, in this model a profit maximizing firm chooses a quantity such that the losses from current period sales are balanced by the option of receiving export licenses in the case of a VER in the future period. An interesting result which comes out of this paper is that a departure from free trade leads to further distortion of the trade, i.e., any exogenous shock which raises the probability of a future VER results in increased dumping in the current period, and increase in total volume of import in a country in turn increases the probability of VER in

the future if the probability of future VER depends on current import volume. This is what Anderson calls "domino dumping". So, the inter temporal linkages provide a motivation for a competitive firm to dump in this model.

It is commonly believed by the general public and also by politicians that dumping hurts the importing country. This has led to the demand for and the consequent enactment of the antidumping laws. In general, governments view antidumping laws as instruments that help restore free trade equilibrium, i.e., pre-dumping equilibrium. Governments also try to justify these antidumping laws by pointing out that since it has been agreed upon at all bilateral and multilateral forums that dumping is an "unfair" trade practice, therefore, any instrument to curb such practice is desirable.

The original theoretical rationale for antidumping laws comes from Viner (1923). He argues that antidumping laws may be needed to protect domestic consumers from predatory dumping. The idea was that foreign firms may deliberately set prices low enough to drive existing domestic firms out of business and establish a monopoly and, later on, as a monopolist it can more than recoup its losses by exploiting its market power. Viner describes three major forms of dumping: short run, sporadic, and long run. Among the three, only the second type of dumping justifies reaction in his view, as only this form of dumping can be labeled as anti-competitive. Domestic firms should be able to adjust to the first form, and the gains to the consumers outweigh the losses to the domestic producers in the case of long run dumping.

It is observed by many (in the U.S., EC and also in other countries) that antidumping laws are becoming a very attractive route for firms to obtain relief from foreign competition as *safeguard laws* are not very easily accessible. Although there is an extra burden of proof associated with antidumping procedures, the injury requirements

under antidumping laws are easier to satisfy than those under safeguard procedures. The safeguard procedures require "serious injury" where as simple "material injury" is enough to invoke antidumping laws [4]. Serious injury is a much more stringent criterion than material injury. In most countries safeguard procedures also require policy makers to take into account the economy wide effect of any protective action and relief from such protection is limited in duration.

Like many other policies, antidumping laws are abused. It has been observed by many that domestic firms often clamor for invoking the antidumping laws just because foreign firms are selling at prices that are lower than theirs. The complexity of the antidumping legislation and procedures have created an environment where the investigators tend to show that dumping is occurring even in cases where foreign and domestic prices are identical. In other instances, political considerations seem to compel the investigating agencies to try to maximize the probability of an affirmative finding in an antidumping case [5]. Handley (1988, 1989) outlined such situations where EC investigation procedures appear to be biased in term of finding dumping.

It has been mentioned earlier that governments react to dumping by imposing tariffs and justify these actions on the grounds of restoring free trade equilibrium. It can be argued that these antidumping laws are inferior instruments to remedy unfair trade practices because they do not address the sources of the problem, which in case of dumping are the barriers that segment the markets. Dixit (as Dixit (1988) discussed

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[4]According to Finger(1991) from 1975 to 1979, the U.S. government processed 245 antidumping and countervailing duty cases or some 50 cases per year. in the 1980s, the case load rose even higher, to 774 cases between 1980 and 1988, or 86 cases a year. By comparison, there have been only four escape-clause cases a year, cases in which an industry saught protection from import competition without accusing the foreign seller of employing or benefiting from unfair practices.

[5]Finger(1991) says, "The U.S. government almost always finds that the foreign exporter is unfair or is benefiting from the unfair actions of its government. Only 11 percent of dumping and subsidy determinations result in negetive determinations.

earlier) also finds no justification for reacting against dumping by imposing tariff. On the contrary he shows that decreasing tariff can be welfare maximizing for a country in case of dumping by an exporter. But antidumping tariff has no correspondence to the dumping margin in Dixit model.

Because of the ease with which antidumping laws are being used these days in different countries, the laws themselves are becoming constraints in firms' decision making. The mere presence and potential threat of antidumping laws affect the behavior of both importing as well as exporting firms. The threat of antidumping actions can lead domestic and exporting firms to alter the scale and production decisions. Staiger and Wolak(1992) show how a threat of filing an antidumping suit leads an exporting firm to adjust its capacity and allocation of that capacity between domestic and foreign markets. Staiger and Wolak set up a model in which the domestic industry is competitive whereas the foreign exporters are cartelized. The foreign monopolist can sell in both foreign as well as in the domestic markets while the domestic firms can only sell in the domestic market since they are denied access to the foreign market through highly protective barriers. The domestic demand is deterministic ($D = \alpha - P$) whereas the demand in the foreign market is stochastic ($D^* = \alpha^* - P^*$). All variables with asterisks are associated with the foreign country, e.g., D^* denotes the foreign demand, P^* is the price in the foreign market, and α^* is i.i.d random variable with the distribution function $F(\alpha^*)$ which has full support on the interval $[\underline{\alpha}^*, \bar{\alpha}^*]$. All variables without asterisks denote identical functions for the domestic market with an exception that α is deterministic. The technology is such that all domestic firms have identical constant long run marginal cost before the capacity is installed and constant short run marginal cost after the capacity is installed. The authors assume zero short run marginal costs in both countries for analysis

throughout the paper. They analyze the decision making of the firms (both domestic and foreign) in different trading environments. In the first case no antidumping law exists in the domestic country, in the second scenario domestic firms have access to antidumping laws, and in the third case tacit collusion among domestic and foreign firms is explored in the presence of antidumping laws.

In all the cases decisions are made sequentially. First the foreign firm chooses the capacity (K^*) at r^* per unit cost before the demand in the foreign market is revealed. After the foreign demand is realized, the monopolist sets the price P^* and at this price quantity q^* is sold in the foreign market such that:

$$q^*(\alpha^*, P^*, K^*) = \min[K^*, D^*(\alpha^*, P^*)]$$

The export level (x^*) is than automatically determined as the residual of the foreign capacity (K^*) and the sales (q^*):

$$x^*(\alpha^*, P^*, K^*) = K^* - q^*(\alpha^*, P^*, K^*)$$

Then the domestic firms take the foreign export capacity x^* as given and act like followers in the Stackelberg leadership model and choose a capacity K at a per unit cost of r. It is also assumed that the domestic long run marginal cost lies between the foreign long run and short run marginal costs which implies:

$$r^* > r > 0$$

In the last stage foreign and domestic firms pick a price simultaneously in the domestic market. It is demonstrated, in the case of no antidumping laws, that all firms will choose a price $\overline{P}$ such that $\overline{P} = r$ under certain plausible conditions. One of these conditions is that the domestic demand at this price is greater than the export capacity $D(\overline{P}) > x^*$, therefore, the residual demand for the domestic firms is positive at this price. The domestic capacity is then, $\hat{K}(x^*) = D(\overline{P}) - x^*$. The authors show at this point that there exist a unique equilibrium at the price $\overline{P}$, i.e., no firm has any incentive to pick a price other than $\overline{P}$ since all the firms are able to dispose of entire capacity at this price. The condition of zero economic profits for the domestic firms is also satisfied at this price. Therefore, in equilibrium, the domestic industry chooses a capacity $\hat{K}(x^*)$. The optimal capacity for the foreign firm is determined through maximization of its expected profits $E\pi^*(K^*)$. There is range of foreign demand $\left[\alpha_1^* \le \alpha^* \le \bar{\alpha}^* \right]$ over which the foreign capacity becomes binding for the foreign market sales. This means that the foreign firm exports only if the realized foreign demand is smaller than α_1^*. The foreign market sales are represented by the following expression:

$$q^*(\alpha^*, K^*) = \begin{cases} K^*, & \text{for } \alpha^* \ge \alpha_1^*(K^*) \\ D^*(\alpha^*, P^*(\alpha^*)), & \text{for } \alpha^* < \alpha_1^*(K^*) \end{cases}$$

The expected profits of the monopolist can, therefore, be written as follows :

$$E\pi^*(K^*) = \int_{\alpha_1^*(K^*)}^{\bar{\alpha}^*} P^*(\alpha^*,K^*).K^*dF(\alpha^*)$$

$$+ \int_{\underline{\alpha}^*}^{\alpha_1^*(K^*)} \{P^*(\alpha^*).D^*(\alpha^*,P^*(\alpha^*))$$

$$+ \overline{P}.x^*(\alpha^*,K^*)\}dF(\alpha^*) - r^*K^*$$

Maximization of the above expected profit function over K^* yields a unique capacity choice (K_0^*) for the foreign monopolist. During the periods when the foreign demand is sufficiently high, i.e. $\alpha^* > \alpha_1^*(K_0^*)$, the monopolist only sells in the foreign market. But during the times when the foreign demand is low ($\alpha^* < \alpha_1^*(K_0^*)$) the monopolist sells $D^*(\alpha^*,P^*(\alpha^*))$ at price P^* in the foreign market and the excess is sold in the domestic market at a price $\overline{P} < P^*$. The price charged by the monopolist in the domestic market ($\overline{P}$) is less than what it charges in the foreign market (P^*) and at this domestic price the monopolist is only able to cover its short run marginal cost but not its long run marginal cost. This means that it is engaged in dumping.

In the second case presence of antidumping laws in the domestic country affects the behavior of both domestic and foreign firms. In this environment where the domestic industry has access to antidumping laws, it compares the cost and benefits of bringing an antidumping suit against the foreign exporting firm. The total cost to the domestic firms of filing an antidumping case is FK. And the benefit is the change in the profits of the domestic firms.

$$\Delta\pi(x^*,K,F) \equiv [P(K) - F - P(K + x^*)]K = (x^* - F)K.$$

Therefore, the domestic industry will file an antidumping suit if and only if $\Delta\pi(x^*,K,F) \geq 0$. This implies that an antidumping case will be filed against the foreign

firm if the exports reach or exceed a critical level $\hat{x}^*$ such that $x^* \geq F \equiv \hat{x}^*$. It is

assumed here that a successful antidumping suit against the foreign monopolist precludes

the firm from exporting any quantity. Therefore, the threat of an antidumping suit affects

the foreign monopolist's choice of capacity in the first place. Since the export capacity

depends on the foreign capacity (K^*) and the realization of the foreign demand (α^*), there

is a range $\alpha^* \in \left[\alpha_1^*, \bar{\alpha}^* \right]$ where there are no exports by the foreign firm, but when α^*

takes the value α_2^*, exports reach the critical level $\hat{x}^*$. In the range $\alpha^* \in \left[\alpha_2^*, \alpha_1^* \right]$,

foreign exports are positive but not enough to invoke an antidumping suit against the

foreign exporter. But for $\alpha^* < \alpha_2^*$, the domestic industry files an antidumping suit and

then there are no exports by the foreign firm. In this case the foreign monopolist either

lowers the foreign price to $\hat{P}^*(\alpha^*; K^*)$ so that the sales increase in the foreign country

and the exports are kept under $\hat{x}^*$ level in order to avoid the antidumping suit, or as the

second option, the foreign monopolist sets the unconstrained monopoly price $\dot{P}^*(\alpha^*)$ in

the foreign market and faces an antidumping suit. Thus, they end up selling nothing in the

foreign market. Under the above specifications, the revenue of the foreign firm,

$R^*(\alpha^*; K^*)$, can be written as follows:

$$
R^*(\alpha^*; K^*) = \begin{cases} P^*(\alpha^*; K^*).K^*, & \text{for } \alpha^* \in \left[\alpha_1^*(K^*), \bar{\alpha}^* \right], \\ P^*(\alpha^*).D^*(\alpha^*; P^*(\alpha^*)) + \overline{P}.x^*(\alpha^*; K^*), & \text{for } \alpha^* \in \left[\alpha_2^*(K^*), \alpha_1^*(K^*) \right], \\ \hat{P}^*(\alpha^*; K^*).D^*(\alpha^*; \hat{P}^*(\alpha^*; K^*)) + \overline{P}.\hat{x}^*, & \text{for } \alpha^* \in \left[\alpha_3^*(K^*), \alpha_2^*(K^*) \right], \\ \dot{P}^*(\alpha^*).D^*(\alpha^*; \dot{P}^*(\alpha^*)), & \text{for } \alpha^* \in \left[\underline{\alpha}^*, \alpha_3^*(K^*) \right], \end{cases}
$$

In the presence of antidumping laws, the expected profits of the foreign monopolist

becomes :

$$E\pi^*(K^*) = \int_{\alpha^*}^{\tilde{\alpha}^*} R^*(\alpha^*;K^*)dF(\alpha^*) - r^*K^*$$

Maximization of this expected profit function over the choice variable K^* and then solving the first order conditions give a different capacity choice (K_1^*) for the foreign monopolist in the presence of antidumping laws in the domestic (importing) country. The capacity choices made by the foreign firm in the presence and in the absence of domestic antidumping laws are then compared by evaluating the first order conditions of expected profit maximization in the case when there are no antidumping laws, at the optimal capacity choice K_1^*, made in the presence of antidumping laws. It is demonstrated that $K_1^* < K_0^*$, which means that the optimal capacity reduces for the foreign firm in the presence of antidumping laws in the domestic country and so does the α_1^*, i.e. now $\alpha_1^*(K_1^*) < \alpha_1^*(K_0^*)$.

Now, in the same environment, the effects of a tacit collusion among the domestic industry and the foreign monopolist are studied. Obviously, such a collusion can only be sustained if the gains from adhering to the agreement to each concerned party outweigh the losses from breaking this self-enforcing agreement. It implies that the domestic firms can not have a one-time gain from breaking the agreement because perfect competition in the domestic market means that all domestic firms will have zero economic profit in equilibrium. So the incentive for the domestic industry to adhere to the agreement requires the foreign firm to keep its exports below $\hat{x}^*$ level. The foreign monopolist gains from the agreement only when the foreign demand is sufficiently low, i.e. $\alpha^* < \alpha_2^*$ and thus, the exports exceed the $\hat{x}^*$ level. The present discounted value of cooperative agreement to the foreign monopolist is denoted by ω^*. The monopolist sets the price $\tilde{P}^*(\alpha^*;K^*,\omega^*)$

in the foreign market and export no more than $\hat{x}^*$ in order to avoid an antidumping suit. Its revenues are then :

$$R^*(\alpha^*;K^*,\omega^*) = \tilde{P}^*(\alpha^*;K^*,\omega^*).D^*(\alpha^*;\tilde{P}^*(\alpha^*;K^*,\omega^*)) + \overline{P}\hat{x}^*$$

As an other alternative it sets the unconstrained monopoly price $\dot{P}^*(\alpha^*)$ and faces an antidumping suit, in this case its revenues are :

$$R^*(\alpha^*) = \dot{P}^*(\alpha^*).D^*(\alpha^*;\dot{P}^*(\alpha^*))$$

The foreign monopolist has to choose between these two alternatives and the authors show that since the cooperative equilibrium can be sustained with price $\tilde{P}^*(\alpha^*;K^*,\omega^*)$ over a certain range of α^*, therefore, the monopolist pursues the suit avoidance policy and limits the exports under $\hat{x}^*$ level without changing the monopoly price in the foreign market. Given a level of capacity in the foreign country, this policy then, results in some of the capacity being unused and in order to sustain the cooperation the foreign monopolist has to abstain from using this unused capacity. The expected profits of the monopolist under cooperation are then as follows :

$$E\pi^{*c}(K^*;\omega^*) = \int_{\underline{\alpha}^*}^{\bar{\alpha}^*} R^*(\alpha^*;K^*;\omega^*)dF(\alpha^*) - r^*K^*$$

The first order condition from the optimization of the above cooperative expected profit function implicitly defines the foreign capacity choice as a function of ω^* in equilibrium, $K_2^*(\omega^*)$. It is demonstrated, then, for $\omega^* > 0$, the optimal capacity choice under self-enforced-cooperative agreement $(K_2^*(\omega^*))$ is such that : $K_0^* > K_2^*(\omega^*) > K_1^*$.

Staiger and Wolak demonstrate that the optimal decisions of the firms are affected by the presence of antidumping laws in the importing country. They show that the foreign monopolist's optimal capacity level reduces when the domestic country has antidumping laws, even during the periods when the domestic firms do not file any antidumping suit against the exporter. As a result the trade volume (in this case exports) also reduces in the presence and/or threat of antidumping laws. The capacity choice and thereby the trade volume is also affected by the possibility of a tacit collusion between the foreign and domestic firms. Although the capacity, in this case, is still smaller as compared to the one in absence of antidumping laws, but greater than the one when there was no possibility of cooperation among the foreign and domestic firms in the face of antidumping laws in the importing country.

The problem with Staiger and Wolak model is that it is not very interesting in a sense that there is no political motivation for invoking the antidumping laws in this model. Even if dumping takes place, no one hurts in this model because the domestic market is assumed to be perfectly competitive and no producer surplus is lost in the domestic country when the foreign firm sells its output in the domestic market.

As the results from the standard international trade theory [6] show that trade protection generally increases the welfare of the protected industry, primarily the antidumping laws are aimed at protecting the welfare of domestic producers, although predation is usually mentioned as one rationale for having the antidumping laws.

Our objective is to further analyze the effects of antidumping laws. We will set up a simple partial equilibrium duopoly model, similar to the one by Brander and Spencer,

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[6] The Stolper-Samuelson Theorem says that, in a two-country framework, trade protection which raises the price of an importable good unambiguously increases the real returns to the fector intensively used in production of that good.

and examine the effect of antidumping laws or even the presence of antidumping on firms' decision making. For the simplicity we will restrict the analysis in our model to one way trade.

CHAPTER III

MODEL

In order to analyze the firms' behavior in the presence of antidumping laws, we will use a simple deterministic duopoly model, which is unlike the one by Staiger and Wolak since that model can not capture the full effects of antidumping law due to the presence of competitive a market in the home country. In our duopoly model, two almost identical firms are located in two distinct countries: home country (H) and a foreign country (F), and produce an identical product which is sold in both countries. As in Staiger and Wolak, only one way trade is allowed in this model, one reason for that could be that the foreign country has very strict trade restrictions which prohibit any imports in the country F, whereas the home country does not have any such restrictions on imports. Therefore, the firm located in the home country can not sell in the foreign country but the foreign firm, which is a monopolist in its own country, competes with the home firm in the home country. Although there is a transportation cost (t) for shipping a unit of the good from one country to another, the foreign firm is assumed to produce in only one (the foreign) country due to the large fixed cost associated with installing a new plant at a different place.

We assume linear demand functions for this product in the two countries which look as follows:

Demand in the home country is

$$P_h = A - \beta(Y_h + X_h) \tag{3.1}$$

and demand in the foreign country is

$$P_f = \alpha - \beta\left(X_f\right).$$ (3.2)

As mentioned, the foreign firm is a monopolist in the foreign market and plays Nash duopoly game in the home market with the home firm. We set up the model in such a way that both firms make decisions in two stages.

Stage I

In the first stage both firms choose their capacity levels simultaneously. The home firm chooses its capacity (Y_t) at a capacity or fixed cost $\eta(Y_t)$ and the foreign firm also chooses its capacity level (X_t) at a fixed or capacity cost $\overline{\eta}(X_t)$

Stage II

In the second stage both firms simultaneously choose their sales for the home and the foreign market. The home firm only has to choose its sales in the home market Y_h s.t $Y_h \leq Y_t$. The foreign firm also chooses its sales for the home market and for the foreign market such that the total sale in both markets do not exceed the capacity chosen at the stage I, i.e., $X_h, X_f \ni X_h + X_f \leq X_t$. The Game Tree (Figure I) shows this decision process by both firms.

We will analyze firms' behavior in two scenarios:

i. The first situation is when there are no antidumping laws present in any country. Hereafter we will refer to this as the unconstrained case. In this case the foreign firm acts as monopolist in the foreign country because the foreign
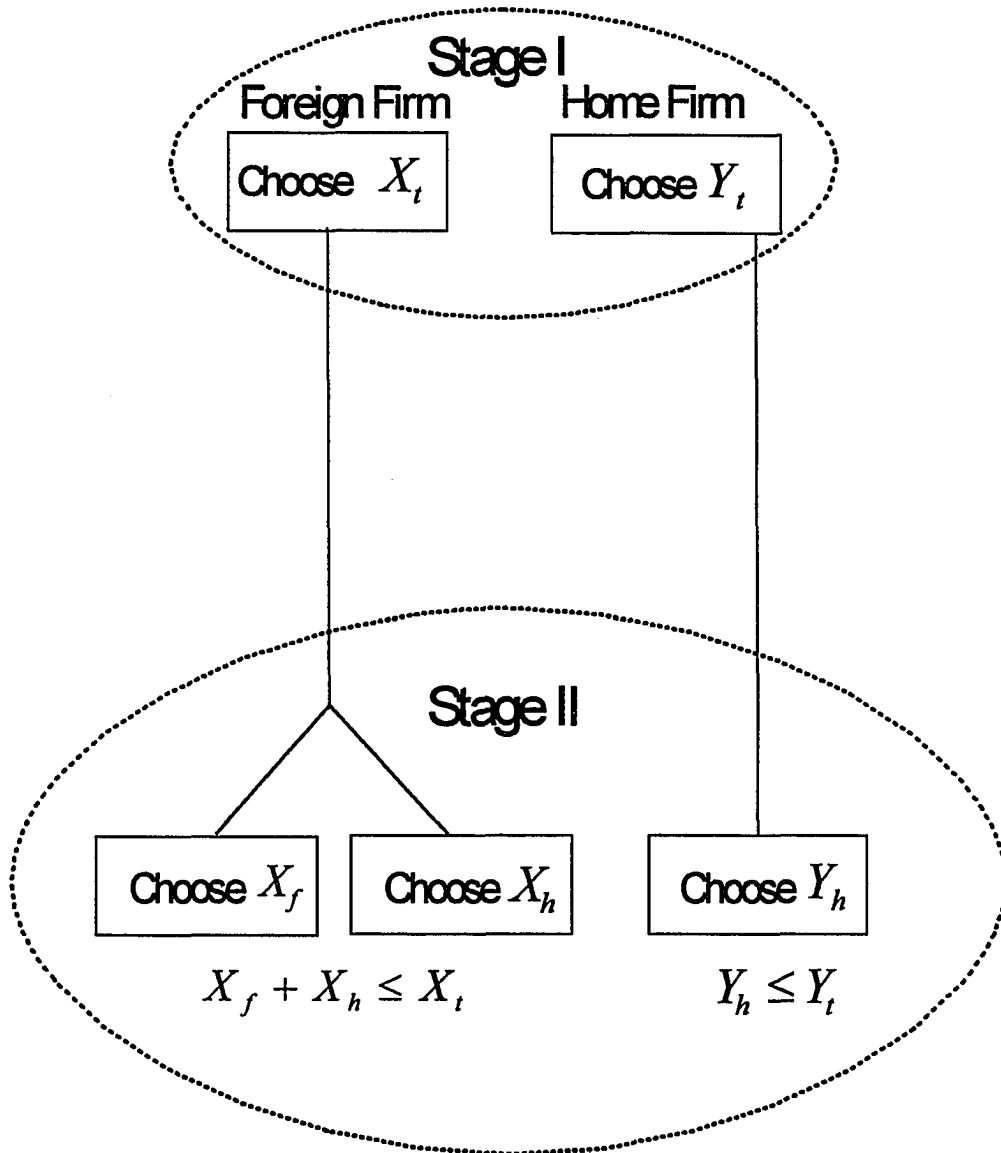
Figure I: Game Tree

country has a prohibitive tariff which does not allow the home firm to sell in the foreign market. In the home country where the foreign firm competes with the home firm, they play a Nash duopoly game.

ii. The second case is where the antidumping law comes into effect in the home country and imposes a constraint on the foreign firm. According to the US, as well as GATT antidumping codes, dumping is considered to have occurred if an exporter charged a price in an import market which was less than the price charged in the exporting country for the same good plus transportation costs. Therefore an antidumping tariff (τ) is imposed on the imports if such a discrepancy in prices in the two markets is observed. The antidumping tariff (τ) is some function of the dumping margin[1] $[(P_f + t) - P_h]$.

The other studies which analyze firms' behavior in the presence of antidumping laws in the importing country are Gruenspecht(1988) and Staiger and Wolak(1992) and they treat antidumping tariffs as prohibitive. Gruenspecht, who uses the cost criterion for the assessment of dumping, finds it profitable for a firm to sell below its current marginal cost and therefore dump in order to take advantage of lower costs in the next period due to learning effect. In this setting he demonstrates an equilibrium in mixed strategy where in certain cases, due to the presence of anti dumping law in the home country, the foreign exporter is totally shut out of the home market. Similarly Staiger and Wolak also prohibit the foreign firm from selling anything in the home market in the wake of a successful antidumping suit against it. However, antidumping tariffs are not automatically

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[1]The US Commerce Department calculates the dumping margin by comparing each sale in the United States by the foreign firm to a single weighted average exporting country price or a single "constructed value" (including all costs plus a statutory 8% profit). Because there is no uncertainty in our model, sales below costs will not occur. Therefore, we ignore the issue of "injury" in deciding when dumping laws are invoked.

prohibitive, but depend on the margin, and thus successful antidumping cases do not entirely eliminate the imports from a firm which was the target of an antidumping suit. We will try to show this by demonstrating that it may be optimal, in certain situations, for a firm to dump in the presence of antidumping laws and pay the antidumping penalties[2].

The duopoly setting makes the dynamics more interesting because the presence of the antidumping law in the home country gives a first play advantage to the domestic firm. The sales of the foreign firm in the home market are now a function of the home firm sales. Since the price in the home market depends both on the home firm's sale as well as sales of the foreign firm in the home market, therefore, the home firm may flood the home market with its output. This results in a price so low that if the foreign firm sells anything in the home market it would be subject to an antidumping suit and would be paying penalties. We will analyze both home and foreign firm behavior in this context.

Antidumping Tariff Rule

The tariff rule under antidumping law is not like other import tariffs which are exogenously determined prior to the exporting firm's output and export decisions and levied on all levels of imports. The antidumping tariff only kicks in when the price in an import market is less than the price in the exporting country plus transportation cost. Thus the antidumping tariff is not differentiable over the entire range of the exporting firm's sales in the import market. The antidumping tariff rule (τ) that we are going to use is as follows:

$$\tau = \delta\left[\left(P_f + t\right) - P_h\right] \qquad \text{where} \qquad (3.3)$$

---

[2] One respect in which the antidumping tariff is different than other import tariffs is that once imposed, the antidumping tariff is usually permanent.

$$\delta = \begin{cases} \varepsilon & \text{if} & \left(P_f + t\right) > P_h \\ 0 & \text{if} & \left(P_f + t\right) < P_h \end{cases} \quad {}^{3.}$$

(3.4)

This implies that at a given level of home firm's sales $\left(Y_h\right)$ and the foreign firm's sales in the foreign market $\left(X_f\right)$:

$$\exists \quad \hat{X}_h \text{ s.t. } X_h \le \hat{X}_h \qquad \delta = 0 \quad \& \quad \tau = 0 \quad \text{and}$$

(3.5)

$$\forall X_h > \hat{X}_h \qquad \delta = \varepsilon \quad \& \quad \tau > 0$$

So this type of antidumping rule will effect the optimal response of each firm to its rival's changes in the sales in the import market.

The presence of such antidumping law causes non concavity in the home firm's profit function which later results in discontinuities in the home firm's stage I reaction function. Obviously if the Nash equilibrium results in dumping, enactment of antidumping laws would affect this equilibrium. An interesting situation to be analyzed is the one when the Nash equilibrium, in the absence of antidumping laws in the home country, does not result in dumping, i.e., $P_f + t > P_h$ in equilibrium. We shall show that like Gruenspecht(1988), the introduction of antidumping laws may affect even this equilibrium. Unlike Gruenspecht, we show multiple local equilibrium may occur.

We also assume that both firms produce at constant marginal cost. Therefore, under the above specified conditions, the profit functions for the two firms look as follows:

The home firm's profit functions

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[3]The law usually recommend antidumping tariff equivalent to the dumping margin, i.e., typically $\varepsilon = 1$ but we allow ε to take any value to investigate welfare implications of the "optimal" rule.

$$\pi_h(Y_h, X_h + Y_h) = P_h(X_h, Y_h)Y_h - C(Y_h) - \eta(Y_t)$$

(3.6)

and the foreign firms profit function is

$$\pi_f = \{A - \beta(Y_h + X_h)\}X_h + (\alpha - \beta X_f)X_f - [\overline{C}(X_h + X_f) + \overline{\eta}(X_t)]$$
$$- t(X_h) - \delta[(P_f + t) - P_h]X_h$$

(3.7)

where the variables with subscript (h) are associated with the home market, and the variables with subscript (f) are associated with the foreign market. All the variables are defined below.

Variables

π_h Profit of the home firm.

π_f Profit of the foreign firm..

P_h Price in the home market.

P_f Price in the foreign market.

X_h Foreign firm's sales in the home market.

X_f Foreign firm's sales in the foreign market.

Y_h — Home firm's sales in the home market.

X_t — Foreign firm's capacity.

Y_t — Home firm's capacity.

$\overline{C}$ — Foreign firm's cost function.

C — Home firm's cost function (C and $\overline{C}$ are scalers here).

$\eta(Y_t)$ — Home firm's fixed or capacity cost.

$\overline{\eta}(X_t)$ — Foreign firm's fixed or capacity cost.

t — Per unit transportation cost.

τ — Antidumping tariff.

Solution Strategy

   The solution for this type of two-stage games is obtained by solving backward; we assume a subgame perfect Nash solution. Given X_t and Y_t, we find the Nash solution for stage II; then, given these rules, the stage I solutions are found. Therefore, for our model, first the home firm and the foreign firm optimize their objective functions over sales in the home and foreign, resulting in the following.

$\overline{Y}_h(Y_t, X_t,$ parameters of the model)

$\overline{X}_h(Y_t, X_t,$ parameters of the model) $\qquad\qquad$ (3.8)

$\overline{X}_f(Y_t, X_t,$ parameters of the model)

After this we solve for the Stage I problem of both firms, which means that the home firm and the foreign firm maximize their respective profits with respect to Y_t and X_t and find:

$$Y_t\left[\overline{Y}_h(\ldots), \overline{X}_h(\ldots)\right]$$
$$X_t\left[\overline{Y}_h(\ldots), \overline{X}_h(\ldots), \overline{X}_f(\ldots)\right]$$

(3.9)

By substituting $\overline{Y}_h$, $\overline{X}_h$, and $\overline{X}_f$ into the above we get the following reaction functions for the home and the foreign firm, respectively.

$$Y_t(X_t, \text{ parameters of the model})$$
$$X_t(Y_t, \text{ parameters of the model})$$

(3.10)

And when we solve these two best response functions simultaneously, we get the Nash equilibrium solution for our model.

$$\overset{\bullet}{Y}_t(\text{ parameters of the model})$$
$$\overset{\bullet}{X}_t(\text{ parameters of the model})$$

(3.11)

CHAPTER IV

NO-DUMPING-PENALTY CASE

We use the best response function (reaction function) approach to find the solution to this model. As we have discussed earlier, we would carry out the analysis under two general scenarios

(i) When there are no antidumping laws in the home country or when dumping is not penalized.

(ii) When the antidumping laws are enforced in the home country and the antidumping tariff, which is some proportion of the dumping margin, is imposed on the dumped imports.

In this chapter we will take up the former case and derive the best response functions for both home and foreign firms. We will then characterize the solution of the model under the assumption that the foreign firm does not face any penalty in the situation where the home market price less the transportation cost turns out to be less than the price of the same good in the foreign market.

The antidumping tariff rate, as defined in chapter 3, is equal to some proportion of the dumping margin $\left[\left(P_f + t\right) - P_h\right]$. The tariff rule is given below.

$$\tau = \delta\left[\left(P_f + t\right) - P_h\right] \qquad \text{where} \tag{4.1}$$

$$\delta = \begin{cases} \varepsilon & \text{if} & \left(P_f + t\right) > P_h \\ 0 & \text{if} & \left(P_f + t\right) < P_h \end{cases} \tag{4.2}$$

When expressed in terms of the linear demand functions specified earlier for the home and foreign countries $P_h = A - \beta(X_h + Y_h)$ and $P_f = \alpha - \beta X_f$, respectively, the dumping margin is:

$$\left[(P_f + t) - P_h\right] = \alpha - \beta X_f - A + \beta X_h + \beta Y_h + t \tag{4.3}$$

$$\left[(P_f + t) - P_h\right] = \beta(X_h - X_f) - Z \quad \text{where} \tag{4.4}$$

$$Z = \gamma - \alpha \qquad \text{and}$$

$$\gamma = A - t - \beta Y_h. \qquad \text{Therefore,}$$

$$\tau = \delta\{\beta(X_h - X_f) - Z\} \tag{4.5}$$

The value of δ, which represents the extent of the penalty imposed on the dumping firm, is decided by the Commerce Department and can range between 0 and ∞. The only two previous studies, Gruenspecht(1988) and Staiger and Wolak(1992), which tried to analyze the effects of antidumping law, have treated the value of δ as given at ∞. That essentially meant eliminating all the imports after a successful antidumping case against the foreign supplier, which may not be the case in reality. A paper by Reitzes in the November 1993 issue of International Economic review uses a model that is very much like ours.[1]

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[1] Reitzes's paper appeared after our work was completed.

In this section we will analyze the situation when there is no antidumping law present in any country or no antidumping tariff is imposed , which implies the value of $\delta = 0$. The foreign country, however, still has trade barriers which do not allow the home firm to sell its product in the foreign country. On the other hand the foreign firm can sell in both foreign and home country. We follow the solution strategy described in the earlier section, i.e. solving the Stage II of the game first and the Stage I second. Given the linear demand functions $P_h = A - \beta(Y_h + X_h)$ and $P_f = \alpha - \beta(X_f)$ in the home and the foreign country, respectively, the profit functions of the two firms are given below.

Home firm's profit function:

$$\pi_h = \{A - \beta(Y_h + X_h)\}Y_h - C(Y_h) - \eta(Y_t) \tag{4.6}$$

Foreign firm's profit function:

$$\pi_f = \{A - \beta(Y_h + X_h)\}X_h + (\alpha - \beta X_f)X_f - [\overline{C}(X_h + X_f) + t(X_h) + \overline{\eta}(X_t)] \tag{4.7}$$

All the variables are the same as defined in the earlier section.

Stage II Problem

Given the capacity levels of the foreign and the home firms, X_t and Y_t , the second stage problem of the home firm is choosing the home sales Y_h such that $Y_h \leq Y_t$... But we will restrict our attention to the domain in which the capacity chosen in the first stage is binding in the decision making at the second stage of the game. Therefore, the home firm's objective function is as follows.

$$MAX \underset{Y_h, \lambda}{L_h} = \{A - \beta(Y_h + X_h)\}Y_h - C(Y_h) - \eta(Y_t) + \lambda(Y_t - Y_h) \tag{4.8}$$

First order conditions are:

$$\frac{\partial L_h}{\partial Y_h} = A - 2\beta Y_h - \beta X_h - C - \lambda \leq 0 \tag{4.9}$$

$$\frac{\partial L_h}{\partial \lambda} = Y_t - Y_h \geq 0 \tag{4.10}$$

Since we assumed that the sale of both firms in stage II are constrained by the capacities chosen earlier, therefore, $\lambda > 0$ and equation (4.10) implies that $Y_h = Y_t$, i.e., the home firm will sell everything in the home market that it produces in the first stage. From equation (4.9), we get the value of λ.

$$\lambda = A - 2\beta Y_h - \beta X_h - C \geq 0 \tag{4.11}$$

For the foreign firm the second stage problem is: given the home firm's sales, Y_h, (Y_h will be equal to Y_t,)[2] it has to choose the levels of sales both in the home market (X_h) and in the foreign market (X_f) such that the sales in the two markets do not exceed its capacity level chosen in stage I. Since at this stage we assumed that there is no penalty for dumping in the home country, the foreign firm is not bound by this constraint. Thus the foreign firm's objective function becomes:

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[2] With capacities chosen simultaneously by both firms in stage I, and no uncertainty in the model, neither firm will find it optimal to choose a non-binding level of capacity in that stage.

$$\underset{X_f, X_h, \theta}{MAX} \ L_f = \{A - \beta(Y_h + X_h)\}X_h + (\alpha - \beta X_f)X_f - \overline{C}(X_h + X_f)$$
$$-t(X_h) - \overline{\eta}(X_t) + \theta(X_t - X_f - X_h) \qquad (4.12)$$

Following are the first order conditions.

$$\frac{\partial L_f}{\partial X_f} = \alpha - 2\beta X_f - \overline{C} - \theta \leq 0 \qquad (4.13)$$

$$\frac{\partial L_f}{\partial X_h} = A - 2\beta X_h - \beta Y_h - \overline{C} - t - \theta \leq 0 \qquad (4.14)$$

$$\frac{\partial L_f}{\partial \theta} = X_t - X_f - X_h \geq 0 \qquad (4.15)$$

We assume an interior solution where X_h, $X_f > 0$ and also that the firm does not choose a capacity in the stage I which it can not sell later in the second stage of decision making, i.e., $\theta > 0$. Thus the inequalities of the preceding first order conditions become strict equalities. After defining the following variables.

$\gamma = A - t - \beta Y_h$ and $Z = \gamma - \alpha$, the above first order conditions can be reduced to the following:

$$Z - 2\beta X_h + 2\beta X_f = 0 \qquad (4.16)$$

$$X_t - X_f - X_h = 0 \qquad (4.17)$$

We get the solution for X_h and X_f by using Cramer's Rule:

$$\begin{bmatrix} -1 & 1 \\ 1 & 1 \end{bmatrix} \begin{bmatrix} X_h \\ X_f \end{bmatrix} = \begin{bmatrix} -Z/2\beta \\ X_t \end{bmatrix}$$

$$\begin{bmatrix} X_h \\ X_f \end{bmatrix} = \frac{-1}{2} \begin{bmatrix} 1 & -1 \\ -1 & -1 \end{bmatrix} \begin{bmatrix} -Z/2\beta \\ X_t \end{bmatrix}$$

$$\overline{X}_h = \frac{Z}{4\beta} + \frac{X_t}{2} \tag{4.18}$$

$$\overline{X}_f = \frac{X_t}{2} - \frac{Z}{4\beta} \tag{4.19}^3$$

$$(P_f + t) - P_h = \beta(X_h - X_f) - Z = \frac{-Z}{2} \gtreqless 0 \text{ as } Z \lesseqgtr 0 \tag{4.20}$$

By adding equation (4.13) and equation (4.14), we get the θ as follows:

$$\theta = \frac{\gamma + \alpha}{2} - \beta(X_h + X_f) - \overline{C} > 0 \tag{4.21}$$

And from equation (4.10), we get:

$$\overline{Y}_h = Y_t \tag{4.22}$$

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[3] These solutions of X_h and X_f are valid, provided:

$$\frac{X_t}{2} > \left| \frac{Z}{4\beta} \right| \qquad \text{otherwise}$$

$$Z > 0, \quad \frac{X_t}{2} < \frac{Z}{4\beta} \qquad \Rightarrow \qquad X_f = 0, X_h = X_t$$

$$Z < 0, \quad \frac{X_t}{2} < \frac{-Z}{4\beta} \qquad \Rightarrow \qquad X_h = 0, X_f = X_t$$

At this stage some variables are further regrouped for simplicity. Let L be the value of the first unit sale of the product to the home firm; that is the difference between the intercept of the home country's demand function (A) and the intercept of the home firm's marginal cost $(C + \eta)$, all divided by the slope of the demand function (β) i.e.,

$$L = \frac{A - (C + \eta)}{\beta}.$$

(4.23)

Likewise, let K be the value of the first unit of sale of the product to the foreign firm, that is the difference between the intercept of the foreign country's demand function (α) and the intercept of the foreign firm's marginal cost $(\overline{C} + \overline{\eta})$, all divided by the slope of the foreign country's demand function (β), i.e.,

$$K = \frac{\alpha - (\overline{C} + \overline{\eta})}{\beta}.$$

(4.24)

Define:

$$Y^c = \left[\frac{A - \alpha - t}{\beta} \right]$$

(4.25)

Now $\overline{X}_h, \overline{X}_f$, and θ can be rewritten as:

$$\overline{X}_h = \frac{X_t}{2} + \frac{Y^c - Y_t}{4}$$

(4.26)

$$\overline{X}_f = \frac{X_t}{2} + \frac{Y_t - Y^c}{4} \tag{4.27}$$

$$\theta = \beta \left[\frac{\alpha - \overline{C}}{\beta} + \frac{Y^c - Y_t}{2} - X_t \right] > 0 \tag{4.28}$$

Here note:

$$\left(P_f + t - P_h \right) = \beta \left(Y_t - Y^c \right) \gtreqless 0 \text{ as } Y_t \gtreqless Y^c \tag{4.29}$$

i.e., that dumping occurs when $Y > Y^c$. This gives us one bound on X_t as shown below.

$$X_t^\theta < k + \frac{Y^c - Y_t}{2} = X_{\max} \tag{4.30}$$

where $k = \dfrac{\alpha - \overline{C}}{\beta}$ \hfill (4.31)

Stage I

Now the stage I problem for both firms is to choose their capacity levels given the second stage choices of the home and foreign market sales, $\overline{Y}_h(X_t, Y_t), \overline{X}_h(X_t, Y_t),$ and $\overline{X}_f(X_t, Y_t)$. For the foreign firm it has to choose X_t, given the following profit function.

$$\overset{\bullet}{\pi}_f(X_t, Y_t) = \left(P_h - t - \overline{C} \right) \overline{X}_h(X_t, Y_t) + \left(P_f - \overline{C} \right) \overline{X}_f(X_t, Y_t)$$

$$-\overline{\eta}(X_t) + \theta \left[X_t - \overline{X}_h(X_t, Y_t) - \overline{X}_f(X_t, Y_t) \right] \tag{4.32}$$

49

The above profit function when maximized with respect to X_t, gives:

$$\frac{\partial \overset{*}{\pi}_f}{\partial X_t} = \left(\frac{\partial \overset{*}{\pi}_f}{\partial X_h} \times \frac{\partial X_h}{\partial X_t}\right) + \left(\frac{\partial \overset{*}{\pi}_f}{\partial X_f} \times \frac{\partial X_f}{\partial X_t}\right) + \left(\frac{\partial \overset{*}{\pi}_f}{\partial \theta} \times \frac{\partial \theta}{\partial X_t}\right) + \left(\frac{\partial \overset{*}{\pi}_f}{\partial Y_h} \times \frac{\partial Y_h}{\partial X_t}\right) + \left(\frac{\partial \overset{*}{\pi}_f}{\partial X_t}\right) \quad (4.33)$$

Since we assumed the existence of an interior solution where the foreign firm sells in both home and foreign markets $(X_h, X_f > 0)$, the first three terms in the above expression (4.33) vanish by the complementary slackness condition. Since $Y_h = Y_t$, therefore the fourth term is also equal to zero, $\frac{\delta Y_h}{\delta X_t} = 0$. Thus, the expression reduces to the following.

$$\frac{\delta \overset{*}{\pi}_f}{\delta X_t} = \theta - \overline{\eta} = 0 \quad (4.34)$$

From equation (4.21), we substitute the value of θ into the equation (4.34) and get:

$$\theta = \beta\left[\frac{\alpha - \overline{C}}{\beta} + \frac{Y^c - Y_t}{2} - X_t\right] - \eta = 0 \quad (4.35)$$

and the following best response function for the foreign firm is obtained[4].

$$X_t = K + \frac{Y^c - Y_t}{2} \quad (4.36)$$

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[4]This reaction function is valid if we have an interior solution.

The home firm also has to choose its capacity level Y_t at the first stage, given the second stage home and foreign market sales choices $\overline{Y}_h(X_t,Y_t), \overline{X}_h(X_t,Y_t)$, and $\overline{X}_f(X_t,Y_t)$. Now the home firm's profit function is:

$$\overset{*}{\pi}_h(Y_t,X_t) = (P_h - C)\overline{Y}_h(Y_t,X_t) - \eta(Y_t) + \lambda[Y_t - \overline{Y}_h(Y_t,X_t)] \qquad (4.37)$$

And the optimal choice for the capacity (Y_t) is made as follows:

$$\frac{\partial \overset{*}{\pi}_h}{\partial Y_t} = \left(\frac{\partial \overset{*}{\pi}_h}{\partial \overline{Y}_h} \times \frac{\partial \overline{Y}_h}{\partial Y_t}\right) + \left(\frac{\partial \overset{*}{\pi}_h}{\partial \lambda} \times \frac{\partial \lambda}{\partial Y_t}\right) + \left(\frac{\partial \overset{*}{\pi}_h}{\partial \overline{X}_h} \times \frac{\partial \overline{X}_h}{\partial \overline{Y}_h} \times \frac{\partial \overline{Y}_h}{\partial Y_t}\right) + \left(\frac{\partial \overset{*}{\pi}_h}{\partial X_t}\right) = 0 \qquad (4.38)$$

The envelope theorem ensures that the first two terms in the above expression vanish. The third term has three components and one of them represent response of the foreign firm in the home market to the change in the home firm's sale in that market. All the components of the third term can be obtained from the equations (4.6), (4.18), and (4.22), as given below:

$$\frac{\delta \overset{*}{\pi}_h}{\delta \overline{X}_h} = -\beta \overline{Y}_h \qquad (4.39)$$

$$\frac{\delta \overline{X}_h}{\delta \overline{Y}_h} = -\frac{1}{4} \qquad (4.40)$$

$$\frac{\delta \overline{Y}_h}{\delta Y_t} = 1 \qquad (4.41)$$

Equation (4.38) becomes :

$$\frac{\delta \overset{\bullet}{\pi}_h}{\delta Y_t} = \frac{\beta \overline{Y}_h}{4} + \lambda - \eta = 0 \tag{4.42}$$

We substitute λ and $\overline{Y}_h$ from equations (4.11) and (4.22) respectively, into the (4.42) and get:

$$\frac{\beta Y_t}{4} + A - 2\beta Y_t - \beta \overline{X}_h - (C + \eta) = 0 \tag{4.43}$$

or

$$\beta \left[\frac{A - (C + \eta)}{\beta} - \frac{7}{4}Y_t - \overline{X}_h \right] = o \tag{4.44}$$

After making a substitution for $\overline{X}_h$ and rearranging the terms we get the best response function for the home firm.

$$\left(L - \frac{Y^c}{4} - \frac{X_t}{2} - \frac{3}{2}Y_t \right) = 0 \tag{4.45}$$

or

$$Y_t = \frac{4L - 2X_t - Y^c}{6} \tag{4.46}$$

When we solve these stage I best response functions for the foreign and home firms simultaneously, we find the following Nash solution to this unconstrained game[5].

$$X_t^N = \frac{12K - 4L + 7Y^c}{10} \qquad (4.47)$$

and

$$Y_t^N = \frac{4L - 2K - 2Y^c}{5} \qquad (4.48)$$

Figure II is the graphical representation of the unconstrained stage I best response functions of the home and foreign firm and the Nash solution of the unconstrained game. We substitute the Nash solution back into the stage II choice variables, $\overline{Y}_h(X_t, Y_t)$, $\overline{X}_h(X_t, Y_t)$, and $\overline{X}_f(X_t, Y_t)$, and find their reduced forms.

$$\overset{\bullet}{Y}_h = \overset{\bullet}{Y}_t = \frac{2}{5\beta}\left[(A + t) + (\overline{C} + \overline{\eta}) - 2(C + \eta)\right] \qquad (4.49)$$

Similarly, we get $\overset{\bullet}{X}_h$ and $\overset{\bullet}{X}_f$ by substituting Y_t^N and X_t^N into equation (4.18) and (4.19), respectively.

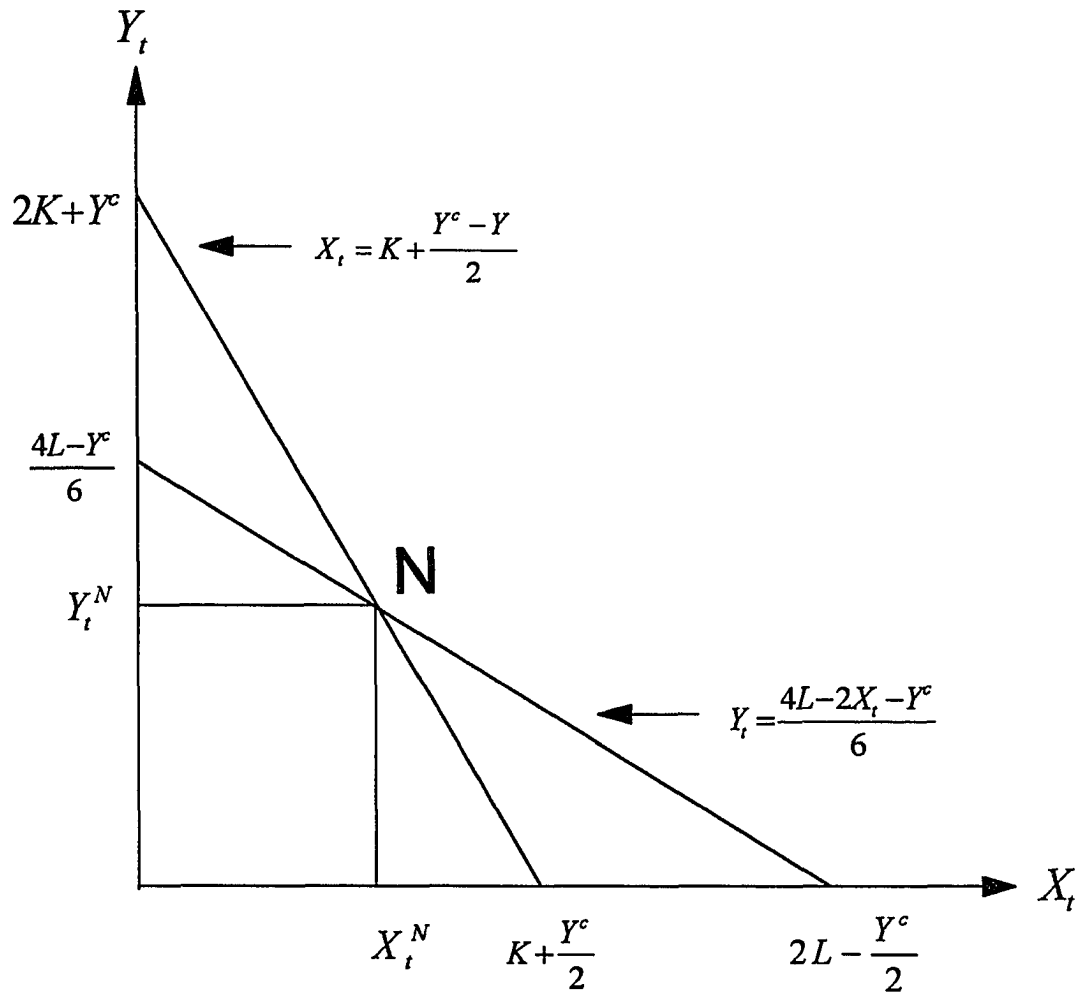[5]We can solve these equations by substitution or by the Crammer's Rule.

Figure II : The Unconstrained Nash Equilibrium

$$\overset{\bullet}{X}_h = \frac{7K + 7Y^c - 4L}{10}$$

(4.50)[6]

$$\overset{\bullet}{X}_f = \frac{K}{2}$$

(4.51)[7]

Lets examine whether or not dumping takes place at stage II in this unconstrained Nash equilibrium (absent antidumping laws). According to our definition, which is consistent with the one used in the US., EEC., and other industrialized countries, dumping is considered to have taken place if the price in the import market is less than the price charged for the same product in the exporting country plus the transportation cost, i.e., if $P_h < (P_f + t)$. Thus, if $P_h - (P_f + t) \geq 0$, there is no dumping. With our linear demand functions, the dumping margin can be represented as:

$$\Delta = \left[P_h - \left(P_f + t \right) \right] = \left[A - \beta Y_h - \beta X_h - \left(\alpha - \beta X_f + t \right) \right]$$

(4.52)

---

[6]The equation (4.18) gives:

$$X_h = \left(\frac{A - \alpha - t}{4\beta} \right) - \frac{1}{4}(Y_t) + \frac{1}{2}(X_t)$$

$$\overset{\bullet}{X}_h = \left(\frac{A - \alpha - t}{4\beta} \right) - \frac{1}{4}\left[\frac{2(A+t) + 2(\overline{C} + \overline{\eta}) - 4(C + \eta)}{5\beta} \right]$$

$$+ \frac{1}{2}\left[\frac{3A + 5\alpha - 7t}{10\beta} + \frac{2(C + \eta) - 6(\overline{C} + \overline{\eta})}{5\beta} \right]$$

[7]The equation (4.19) gives:

$$X_f = -\left(\frac{A - \alpha - t}{4\beta} \right) + \frac{1}{4}(Y_t) + \frac{1}{2}(X_t)$$

$$\overset{\bullet}{X}_f = -\left(\frac{A - \alpha - t}{4\beta} \right) + \frac{1}{4}\left[\frac{2(A+t) + 2(\overline{C} + \overline{\eta}) - 4(C + \eta)}{5\beta} \right]$$

$$+ \frac{1}{2}\left[\frac{3A + 5\alpha - 7t}{10\beta} + \frac{2(C + \eta) - 6(\overline{C} + \overline{\eta})}{5\beta} \right]$$

$$\Delta = Z + \beta\left(X_f - X_h\right) \tag{4.53}$$

and if the foreign firm acts as a profit maximizer then it equates its marginal revenue in the foreign market $\left(\overline{MR}_f\right)$ to its marginal revenue in the home market $\left(\overline{MR}_h\right)$, i.e.,

$$\left(\overline{MR}_h\right) = \left(\overline{MR}_f\right) \quad \Rightarrow \quad P_h - t - \beta X_h - P_f + \beta X_f = 0, \tag{4.54}$$

$$A - 2\beta X_h - \beta Y_h - t - \alpha + 2\beta X_f = 0, \tag{4.55}$$

$$\beta\left(X_f - X_h\right) = -\frac{Z}{2} \tag{4.56}$$

By substituting (4.56) into (4.53), the dumping margin for this model is:

$$\Delta = \frac{Z}{2} \tag{4.57}$$

$Z = A - \alpha - t - \beta Y_h$ and by substituting $\overset{\bullet}{Y}_h$ in the above, we get:

$$Z = \beta\left[\frac{A - \alpha - t}{\beta} - \frac{\left(4L - 2K - 2Y^c\right)}{5}\right] \tag{4.58}$$

$$Z = -\beta\left[4L - 2K - 7Y^c\right] \tag{4.59}$$

Let $J = \left[4L - 2K - 7Y^c \right]$. So if $J > 0$, dumping takes place and when $J < 0$ no dumping occurs. If $J > 0$, the unconstrained Nash equilibrium will result in dumping and if the antidumping law comes into effect at this stage, this equilibrium will change.

This critical value (Y^c) of the home firm's capacity divides the whole space into two regions see Figure III. In the region where $Y_h = Y_t < Y^c$, no dumping takes place, i.e., the optimal sales by the foreign firm in the home country will keep price in the foreign market lower than the price in the home market. In the region where $Y_h = Y_t > Y^c$, the price discrimination rule by the foreign firm will not work and if the foreign firm tries to sell in the home market, dumping occurs and it may find itself subject to antidumping action by the home country.

Even if $J < 0$, but $\overset{\bullet}{Y_t}$ is very close to the Y^c in the unconstrained Nash equilibrium, the enactment or presence of antidumping laws may still affect this equilibrium. In the following chapters we will explore the parameter spaces in some of which dumping will take place and antidumping law may mater, and in some parameter spaces dumping does not occur and, therefore, antidumping laws may not mater.

Let's examine again what $J>0$ mean.

$$J = 4L - 2K - 7Y^c = 4\left[\frac{A - (C + \eta)}{\beta} \right] - 2\left[\frac{\alpha - (\overline{C} + \overline{\eta})}{\beta} \right] - 7\left[\frac{A - \alpha - t}{\beta} \right] \qquad (4.60)$$

$$J = \left[\frac{5\alpha - 3A + 7t + 2(\overline{C} + \overline{\eta}) - 4(C + \eta)}{\beta} \right] \qquad (4.61)$$
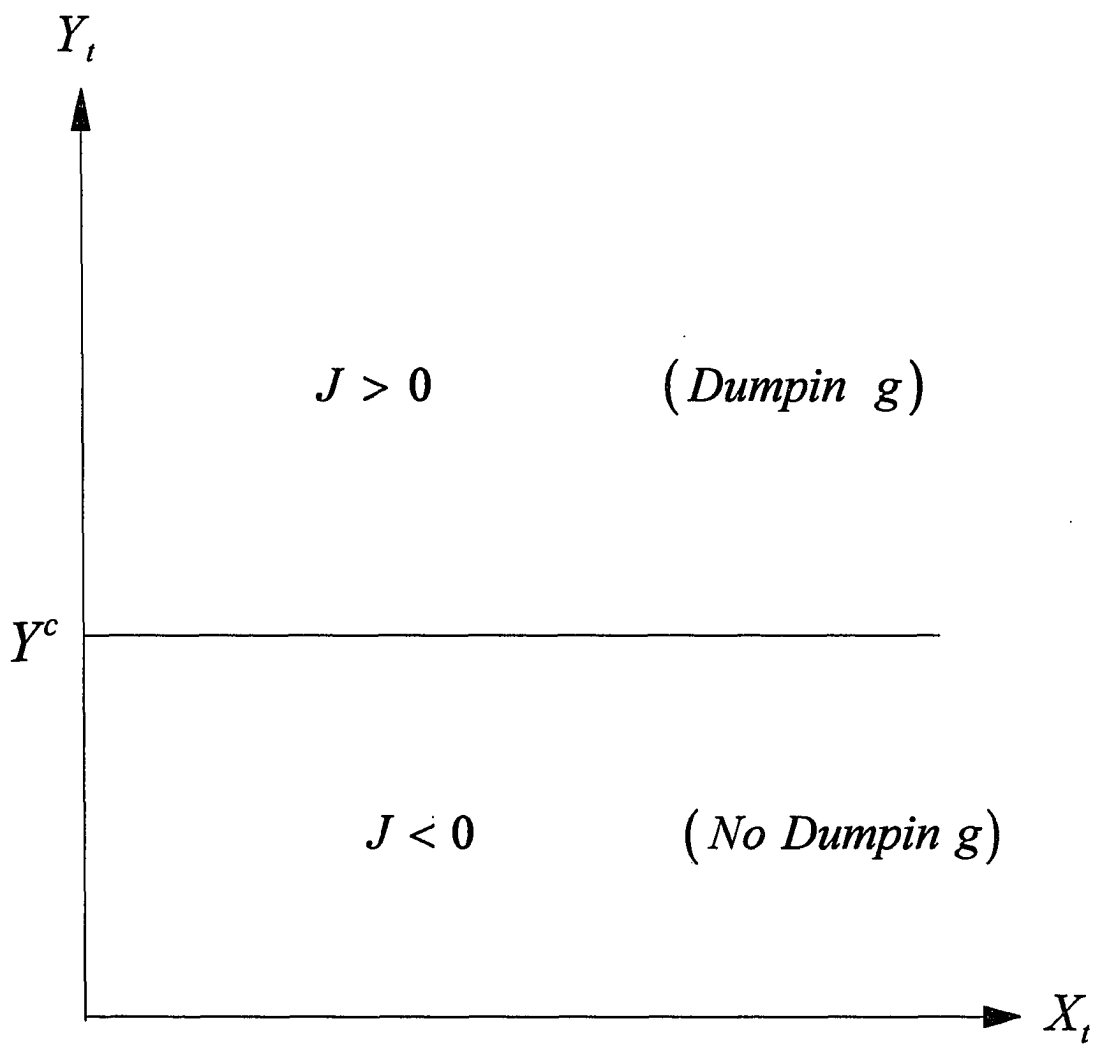
Figure III: Dumping and no Dumping Regions

If both foreign and home markets are similar in size, i.e., $A = \alpha$ and both firms have identical cost structures, i.e., $(C + \eta) = (\overline{C} + \overline{\eta})$, then equation (4.61) implies that dumping takes place ($J>0$) because $\alpha - (C_{-}\eta)) > 0$. On the other hand dumping may not automatically result if:

i) the home country is very large compared to the foreign country, e.g. USA being home and Taiwan being the foreign country, and therefore demand is higher in the home country (here it means $A >> \alpha$).

ii) the home firm is more efficient than the foreign firm and can produce the product at lower cost than that of the foreign firm, so $(C + \eta) > (\overline{C} + \overline{\eta})$.

iii) there is no or negligible transportation cost, i.e., t is small.

Under the above conditions it is possible for J to be negative and dumping may, thus not occur in equilibrium.

59

CHAPTER V

FOREIGN FIRM AND ANTIDUMPING LAW

In this chapter we look at the situation where antidumping laws are present and enforced in the home country. A special tariff is imposed on the foreign firm whenever it sells its product in the home country at a price that is less than the price it charges in its own country plus the transportation costs from the foreign country to the home country.

These antidumping laws would affect the foreign firm's choices because now to maximize its profits, it can not exercise simple price discrimination in two countries without incorporating this constraint into its decision-making. In this situation the foreign firm essentially has two options. One is to choose its foreign and home market sales in such a way that dumping never occurs (i.e., foreign price plus transportation costs remain less than or equal to the price in the home market). The other option for the foreign firm is to continue to exercise price discrimination and dump in the home market and pay the antidumping tariff.

In the following section we analyze conditions under which the foreign firm avoids dumping and allocates its sales in the home and foreign markets such that the difference between the prices in these two markets is less than the transportation costs, and those situations in which it finds optimal to dump (exercise price discrimination). It is shown in the previous chapter that, if $Y_t > Y^c$ and there is no antidumping law, the foreign firm exercises price discrimination between the two markets and dumping occurs. In this chapter we set up the general problem for the foreign firm and analyze the above mentioned situations.

The antidumping tariff (τ), as we have defined earlier, is some proportion (δ) of the dumping margin:

$$\tau = \delta.\max\left[\left(P_f + t - P_h\right),0\right].$$ (5.1)

We have also discussed that neither firm finds it optimal to choose a capacity at stage I that would be non-binding later at stage II, therefore, $X_t = X_h + X_f$ and $Y_h = Y_t$. Along with this when substitutions are made for

$$P_f = \alpha - \beta X_f,$$ (5.2)

$$P_h = A - \beta(X_h + Y_h), \text{ and}$$ (5.3)

$$Z = A - \alpha - t - Y_h$$ (5.4)

the tariff rule, as a function of the dumping margin, can be rewritten as below

$$\tau = \delta.\max\left[\beta(2X_h - X_t) - Z; 0\right].$$ (5.5)

Now we define $\overset{\bullet}{X}_h$ as the level of foreign sales in the home market such that prices in two countries are the same, thus the dumping margin is zero.

$$\overset{\bullet}{X}_h: \quad \beta(2X_h - X_t) - Z = 0$$ (5.6)

$$\overset{\bullet}{X_h} = \frac{Z}{2\beta} + \frac{X_t}{2} \tag{5.7}$$

This implies that if the foreign firm's sales in the home country are less than $\overset{\bullet}{X_h}$ dumping does not take place and vice versa, i.e.,

If $X_h < \overset{\bullet}{X_h}$ $\Rightarrow$ No dumping.

If $X_h > \overset{\bullet}{X_h}$ $\Rightarrow$ Dumping.

This causes nondifferentiability in the foreign firm's profit function at $\overset{\bullet}{X_h}$.

Given $X_t = X_h + X_f$, the foreign firm's profit function, as shown in the previous chapter, can be written as:

$$\pi_f = \left(P_h - P_f - t\right)X_h + P_f X_t - \tau X_h - \left(\overline{C} + \overline{\eta}\right)X_t \tag{5.8}$$

After we substitute for the inverse demand functions and the antidumping tariff rule, the foreign firm's profits are as follows.

$$\pi_f = (\beta X_t + z - 2\beta X_h)X_h + (\alpha - \beta X_t + \beta X_h)X_t$$
$$- \delta.\max[\beta(2X_h - X_t) - Z; 0]X_h - (\overline{C} + \overline{\eta})X_t \tag{5.9}$$

Given the above profit function, the foreign firm chooses sales in the foreign and home markets at stage II and it chooses its capacity (X_t) at stage I.

Stage II

At this stage, the foreign firm chooses its sales in the home country (X_h) and its sales in the foreign market (X_f) (obtained as $X_f = X_t - X_h$). Therefore, the foreign firm maximizes the above profit function over X_h. Note, however, that there is a nondifferentiability in the foreign firm's profit function at $\overset{*}{X_h} = \dfrac{Z}{2\beta} + \dfrac{X_t}{2}$. Thus, upon differentiating, we get the following derivatives:

$$\frac{\partial L}{\partial X_h} = 2\beta X_t + Z - 4\beta X_h = 0 \quad \text{for} \quad X_h < \overset{*}{X_h} = \frac{Z}{2\beta} + \frac{X_t}{2} \tag{5.10}$$

$$\frac{\partial L}{\partial X_h} = 2\beta X_t + Z - 4\beta X_h - \delta\big[\beta(4X_h - X_t) - Z\big] = 0 \quad \text{for} \quad X_h > \overset{*}{X_h} = \frac{Z}{2\beta} + \frac{X_t}{2} \tag{5.11}$$

When the above first order condition is evaluated at $\overset{*}{X_h}$ as X_h approaches $\overset{*}{X_h}$ from below (the left hand side derivative) and when X_h approaches $\overset{*}{X_h}$ from above (the right hand side derivative), we get the following expressions for the derivatives:

$$\frac{\partial \pi_f}{\partial X_h}\bigg|_{X_h \to \overset{*}{X_h}(from\,left)} = \frac{\partial \pi_f}{\partial X_h}\bigg|_- = -Z \tag{5.12}$$

$$\frac{\partial \pi_f}{\partial X_h}\bigg|_{X_h \to \overset{*}{X_h}(from\,right)} = \frac{\partial \pi_f}{\partial X_h}\bigg|_+ = -\delta\beta X_t - (1+\delta)Z < -Z, \qquad \delta > 0, X_t > 0 \tag{5.13}$$

We have already shown that if $Y_t < Y^c$ (which implies that $Z > 0$), the presence of antidumping laws is irrelevant at stage II. In this case the above derivatives, (5.12) and (5.13), are both negative and hence, for all $X_t > 0$, the antidumping law will not bind. Figure IV below depicts this situation.
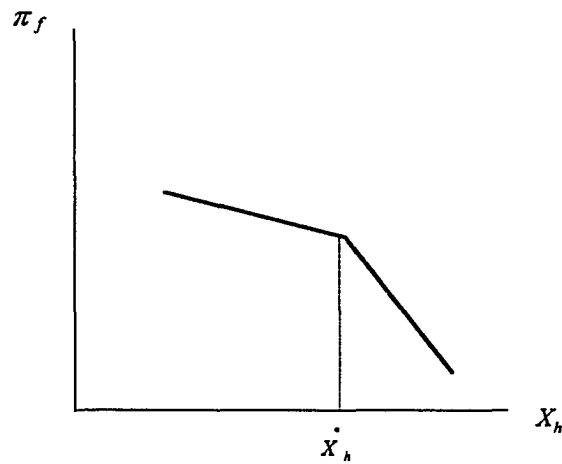

Figure IV: Derivative I

We can, therefore, conclude that if $Z > 0$, the foreign firm's optimal sales in the home country are such that dumping does not take place no matter how severe the dumping penalty may be, i.e.,

$$\overline{X}_h = \frac{Z}{4\beta} + \frac{X_t}{2} < \overset{*}{X}_h \quad \forall \ \delta \tag{5.14}$$

If $Z < 0$ $(Y_t > Y^c)$, there are two possibilities for the optimal choice of X_h:

i. $P_f + t = P_h$, i.e. the foreign price plus the transportation cost is kept equal to the price in the home market. The foreign firm would like to dump, but is discouraged from doing so

by the tariff. Thus, the foreign firm does not pay any dumping tariff, but the presence of the tariff modifies its choice of X_h, and, hence, may alter the stage I choice of X_t.

ii. $P_f + t > P_h$ which means that the foreign firm finds it optimal to dump and pay dumping tariff in equilibrium.

We analyze these cases in a little more detail.

Case I

In this case the foreign firm avoids dumping in the home country, even though it would like to do so in the absence of a dumping tariff. Although there is a positive dumping tariff which is levied on imports if they are found dumped in the home country, in this case the foreign firm (in equilibrium) chooses a level of sales in the home market such that it keeps the price in the home country equal to the price charged in the foreign country plus transportation cost. Thus, the foreign firm does not pay any dumping tariff. This case arises if the first order condition (5.12) is non-negative and (5.13) is non-positive, and, hence, the optimal choice $\overline{X}_h$ would be equal to the critical level $\overset{*}{X}_h$ i.e., :

$$\left. \frac{\partial \pi_f}{\partial X_h} \right|_{\overset{*}{X}_h} = -Z > 0 \tag{5.15}$$

$$\left. \frac{\partial \pi_f}{\partial X_h} \right|_{\overset{**}{X}_h} = -\delta\beta X_t - (1+\delta)Z < 0 \qquad (\text{ see Figure V }) \tag{5.16}$$
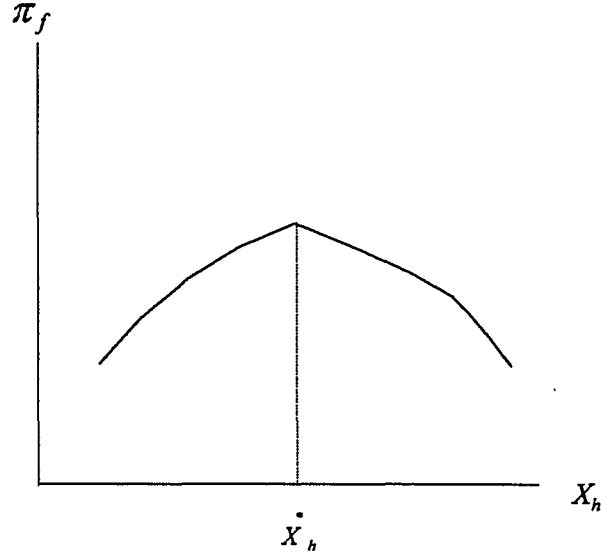
Figure V: Derivative II

This can only be true if $X_t > \left(\dfrac{-(1+\delta)Z}{\delta\beta} \right)$, i.e.,

$$if \quad X_t > \left(\frac{-(1+\delta)Z}{\delta\beta} \right) \quad \Rightarrow \quad \left.\frac{\partial \pi_f}{\partial X_h}\right|_L > 0, \qquad \left.\frac{\partial \pi_f}{\partial X_h}\right|_R < 0, \qquad (5.17)$$

$$then \quad \overline{X}_h = \overset{\bullet}{X}_h = \frac{Z}{2\beta} + \frac{X_t}{2} \qquad\qquad (5.18)$$

Therefore, $\overline{X}_h = \overset{\bullet}{X}_h$ for all (δ, X_t, Z) that satisfy the condition $Z < \left(\dfrac{-\delta\beta X_t}{1+\delta} \right)$.

Intuitively, this case is very likely to occur when the penalty for dumping is very high (large δ) or the foreign firm's capacity is very large. The later implies large foreign sales in the home market on which the dumping tariff is applied.

Case II

This is the situation where the foreign firm, in the presence of antidumping laws in the home country, finds it optimal to keep on exercising price discrimination between foreign and home markets. In this case, the foreign firm's optimal sales in the home market exceed the critical level $\overset{*}{X}_h$, even though this causes dumping ($P_f + t > P_h$) and the firm has to a pay dumping tariff (τ). Unlike Staiger & Wolak (1992) and Gruenspech (1988), the treatment of the antidumping tariff is not restricted to a prohibitive tariff in this model. In our model, the dumping tariff, which is some proportion of the dumping margin, may assume any value between zero and infinity.

The condition under which it is optimal for foreign sales in the home country to exceed $\overset{*}{X}_h$ is:

$$if \quad \frac{-\delta\beta X_t}{(1+\delta)} < Z < 0 \tag{5.19}$$

This gives:

$$\left.\frac{\partial \pi_f}{\partial X_h}\right|_L > 0 \, , \quad \left.\frac{\partial \pi_f}{\partial X_h}\right|_R > 0 \tag{5.20}$$
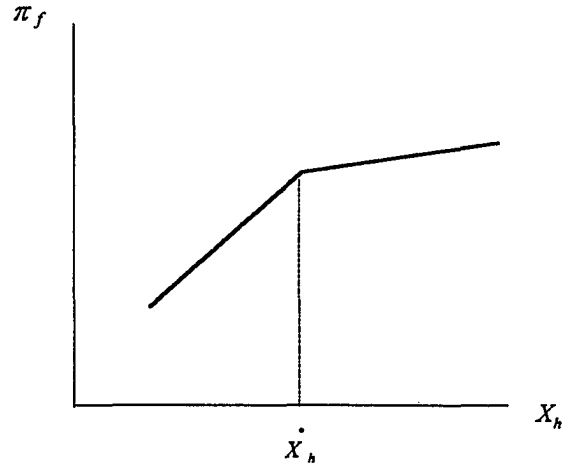
Above derivatives are represented by the Figure VI.

Figure VI: Derivative III

Therefore, the optimal foreign sales in the home country $\overline{X}_h > \overset{\bullet}{X_h}$ for all (X_t, Z, δ) which satisfy the condition $X_t < \left(\dfrac{-(1+\delta)Z}{\delta\beta} \right)$, and so dumping occurs $(\tau > 0)$. The foreign sales in the home country are obtained in this case from equation (5.11) as follows:

$$\overline{X}_h = \frac{Z}{4\beta} + \frac{(2+\delta)}{4(1+\delta)} X_t \qquad\qquad (5.21)$$

The above expression for $\overline{X}_h$ is exactly the same as what we get in the unconstrained case in chapter IV if $\delta = 0$ is substituted in the equation. The foreign firm uses a similar rule, adjusted for dumping tariff, for allocating its sales in the home and foreign countries in this case which it would use in an unconstrained situation But now, since dumping results, it must pay a penalty to the home country and thereby reduces sales in the home country. Further, in this case, the choice of capacity by the foreign firm will be altered (which we will show in the following section). As opposed to case I, this situation arises when the dumping tariff the foreign firm has to pay is small, either due to small a dumping penalty (

small δ) or because the foreign sales in the home markets are not very large because of the small foreign capacity (X_t). Hence, the firm finds it optimal to dump and pay the tariff.

From here onward, we refer to DI as the domain where dumping laws do not matter, i.e., where $Z > 0 (Y_t < Y^c)$ and, therefore, optimal $\overline{X}_h < \overset{*}{X}_h$. The $Z < 0 (Y_t > Y^c)$ space is divided into two regions. DII refers to the domain, where in the presence of a antidumping law in the home country, dumping does not occur, but the antidumping law modifies the firm's behavior ($X_h = \overset{*}{X}_h$ and $\tau = 0$). DIII is the domain in which the foreign sales in the home market exceed the critical level ($\overline{X}_h > \overset{*}{X}_h$), and thus, dumping takes place and $\tau > 0$. The line that separates DII and DIII,

$$Z = \frac{-\delta\beta X_t}{(1+\delta)} \quad \Rightarrow \quad Y_t = Y^c + \frac{\delta}{(1+\delta)}X_t \text{ , is referred to as the boundary (B).}$$

Domain 1 no dumping region as   D I   where $Y_t < Y^c$

Domain 2 where firm avoids dumping as   D II   where $Y^c < Y_t < Y^c + \dfrac{\delta}{1+\delta}X_t$

Domain 3 where firm pays dumping tariff as   DIII   where $Y_t > Y^c + \dfrac{\delta}{1+\delta}X_t$

Boundary of domains 2 & 3 as   B   where $Y_t = Y^c + \dfrac{\delta}{1+\delta}X_t$

These domains are illustrated in Figure VII.

Some important results which we get from the solution of the stage II problem of the foreign firm deserve some special attention. These results are:

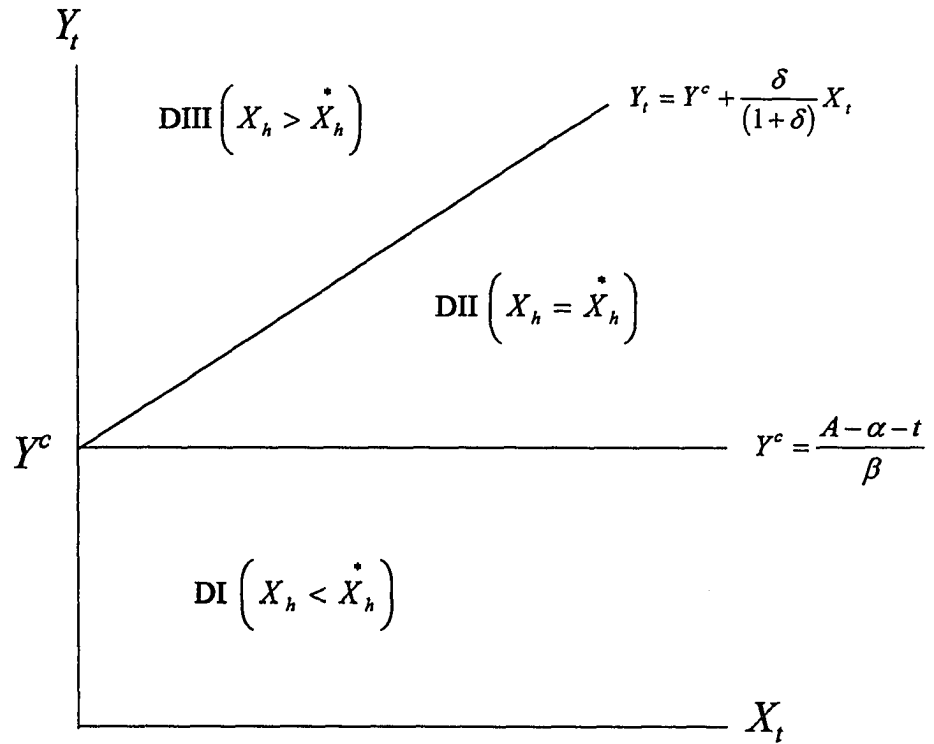a) The antidumping tariff rule which we are using in our model is not differentiable

Figure VII: Domains

everywhere, i.e., $\tau = 0$ if $X_h \leq \overset{*}{X_h} = \dfrac{X_t + Y^c - Y_t}{2}$ and $\tau > 0$ if $X_h > \overset{*}{X_h} = \dfrac{X_t + Y^c - Y_t}{2}$

and this causes non differentiability in the foreign firm's profit function in X_h.

b) The rules that the foreign firm uses to distribute its sales in home and foreign markets. From these rules we get the foreign firm's response to the home firm's sales in the home market, $\left(\dfrac{\partial X_h}{\partial Y_h} \right)$. These rules are different in all three domains. This difference in the

foreign firm's stage II allocation rules has an important bearing on the home firm because it takes into account this response while making the stage I decision. One of the components of the home firm's stage I decision is the response of the foreign firm to the home firm's sales in the home market, which is different in the different domains. This response of the foreign firm, which can also be called the foreign firm's stage II best response function, has different slopes in each domain and, therefore, has kinks at the boundaries of the domains (see Figure VIII). This may, thereby, cause jumps (discontinuity) in the home firm's stage I reaction function.

$$\frac{\delta X_h}{\delta Y_h} = \begin{cases} -\dfrac{1}{4} & \text{if} & \text{D I}\,(\tau = 0) \\[2mm] -\dfrac{1}{2} & \text{if} & \text{D II}\,(\tau = 0) \\[2mm] -\dfrac{1}{4} & \text{if} & \text{D III}\,(\tau > 0) \end{cases} \qquad (5.22)$$
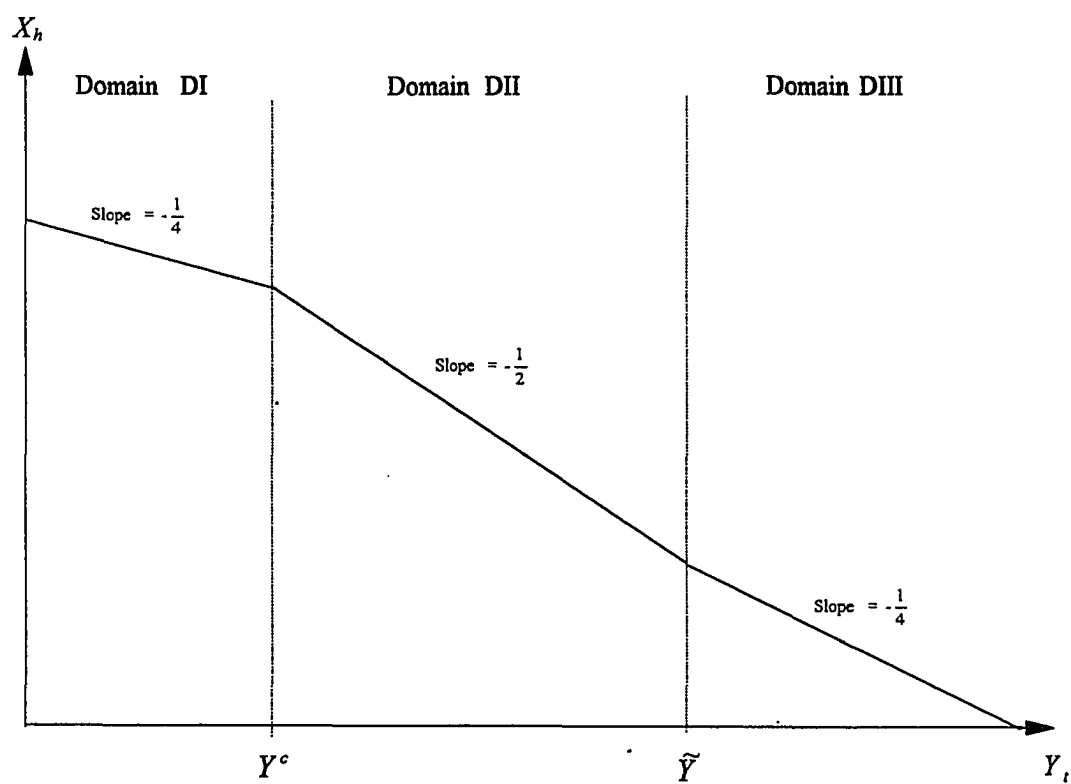
Figure VIII: Foreign Firm's Stage II Reaction Function

As we discussed about the solution strategy in chapter III, these types of two-stage games are solved by backward induction method, i.e., the stage II is solved first and after that the stage I problem is solved. Thus, we can now analyze the stage I problem of the foreign firm.

Stage I

At this stage of the game, the firm chooses its capacity (X_t) and the rule for determining the capacity gives the foreign firm's stage I best response function. We have already set up the foreign firm's profit function (5.8). The foreign firm's profit function at this stage is: $\pi_f(X_t; \overline{X}_h)$, where $\overline{X}_h$ is the optimal value of X_h determined at stage II. When partially differentiated with respect to X_t , the following first order condition is obtained:

$$\frac{\partial \pi_f(X_t; \overline{X}_h)}{\partial X_t} = \left(\frac{\partial \pi_f}{\partial \overline{X}_h}\right)\left(\frac{\partial \overline{X}_h}{\partial X_t}\right) + \frac{\partial \pi_f}{\partial X_t} \tag{5.23}$$

We have shown in the previous section that, if $Z > 0$, then the optimal foreign sales in the home market are: $\overline{X}_h = \frac{Z}{4\beta} + \frac{X_t}{2}$, and $\left.\frac{\partial \pi_f}{\partial X_h}\right|_{\overline{X}_h} = 0$, and dumping does not take place.

Similarly, if $0 < X_t < \left(\frac{-(1+\delta)Z}{\delta\beta}\right)$, then $\overline{X}_h = \frac{Z}{4\beta} + \frac{(2+\delta)X_t}{4(1+\delta)}$, and dumping occurs, but

$\left.\frac{\partial \pi_f}{\partial X_h}\right|_{\overline{X}_h} = 0$. Thus, for these cases the envelope theorem can be used which implies that

the first term, $(\partial \pi_f / \partial X_h)(\partial X_h / \partial X_t)$, in the above first order condition vanishes.

However, if $Z < 0$ and $X_t > \left(\frac{-(1+\delta)Z}{\delta\beta}\right) > 0$, then $X_h = X_h^* = \frac{Y^c - Y_t}{2} + \frac{X_t}{2}$, and the

envelope theorem cannot be applied.

In domain DI, $Z > 0$, then $\overline{X}_h = \dfrac{Z}{4\beta} + \dfrac{X_t}{2}$ $\quad\forall\quad$ X_t, and $\dfrac{\partial \pi_f}{\partial X_h}\bigg|_{\overline{X}_h} = 0$, and thus:

$$\frac{\partial \pi_f\left(X_t; \overline{X}_h\right)}{\partial X_t} = \frac{\partial \pi_f}{\partial X_t} = 2\beta X_h - 2\beta X_t + \alpha - \left(\overline{C} + \overline{\eta}\right) + \delta\beta X_h = 0 \tag{5.24}$$

When value of $\overline{X}_h$ for this domain is substituted in the above, it yields:

$$X_t = K + \frac{Y^c - Y_t}{2} \tag{5.25}$$

For $Z < 0$, we have seen in the previous section that which stage II solution prevails depends, among other things, on the foreign firm's capacity (X_t).

For $X_t > \left(\dfrac{-(1+\delta)Z}{\delta\beta}\right) > 0$, we have found that the foreign firm does not pay any tariff ($\tau = 0$), although the antidumping law binding, and hence $X_h = \overset{\bullet}{X}_h = \dfrac{Y^c - Y_t}{2} + \dfrac{X_t}{2}$,

therefore the envelope theorem cannot be applied, and:

$$\frac{\partial \pi_f\left(X_t; \overline{X}_h\right)}{\partial X_t} = \left(\frac{\partial \pi_f}{\partial \overline{X}_h}\right)\left(\frac{\partial \overline{X}_h}{\partial X_t}\right) + \frac{\partial \pi_f}{\partial X_t}$$

$$= \left(2\beta X_t + Z - 4\beta X_h\right)\left(\frac{1}{2}\right) + 2\beta X_h - 2\beta X_t + \alpha - \left(\overline{C} + \overline{\eta}\right) = 0 \tag{5.26}$$

When substitution for X_h is made, it gives:

$$X_t = K + \frac{Y^c - Y_t}{2} \qquad (5.27)$$

The capacity choice or the best response function in this domain (DII) is identical to what we have found in DI. This case is a typical example of a multi-market monopolist. In the case of linear demand, like our model, when a constraint which prohibits exercising price discrimination is imposed on this monopolist the total output produced by this monopolist remains unaltered. The capacity choice of the foreign firm is not affected, but only the rules of allocating the total output in the two markets are adjusted. Thus, we have identical stage I solution rules for the foreign firm in DI and DII.

However, for $\;0 < X_t < \left(\dfrac{-(1+\delta)Z}{\delta\beta}\right)$, $\overline{X}_h = \dfrac{Z}{4\beta} + \dfrac{(2+\delta)X_t}{4(1+\delta)}$, and therefore,:

$$\frac{\partial \pi_f(X_t; \overline{X}_h)}{\partial X_t} = \frac{\partial \pi_f}{\partial X_t} = 2\beta X_h - 2\beta X_t + \alpha - (\overline{C} + \overline{\eta}) + \delta\beta X_h = 0 \qquad (5.28)$$

yielding:

$$X_t = \left(\frac{(1+\delta)}{4 + 4\delta - \delta^2}\right)\{4K + (2+\delta)(Y^c - Y_t)\}, \qquad (5.29)$$

The above expression represents the foreign firm's solution rule or best response function in domain DIII, which is different than the one in DII, but when these derivatives, (5.26) and (5.28), are evaluated at $X_t = \left(\dfrac{-(1+\delta)Z}{\delta\beta}\right)$, we get:

$$\left\{\left(\frac{\partial \pi_f}{\partial \overline{X}_h}\right)\left(\frac{\partial \overline{X}_h}{\partial X_t}\right)+\frac{\partial \pi_f}{\partial X_t}\right\}\Bigg|_{X_t=\frac{-(1+\delta)}{\beta\delta}Z} = \frac{\partial \pi_f}{\partial X_t}\Bigg|_{X_t=\frac{-(1+\delta)}{\beta\delta}Z} = 4\beta\delta K + (4+6\delta)Z \qquad (5.30)$$

This shows that there is no jump in the foreign firm's solution rule (best response) from DII to DIII, which implies that the profit function is continuous.

When these solution rules are combined over the three domains, the foreign firm's stage I best response function is obtained (Figure IX). Then we can find foreign firm's sales in the foreign market by subtracting foreign sales in the home market (X_h) from its capacity (X_t)

The results of this chapter are summarized as follows:

Domain DI

$$Z > 0 \quad \Rightarrow \quad Y^c > Y_t \qquad \text{(dumping never occurs)} \qquad (5.31)$$

$$X_h < \overset{*}{X}_h \quad \Rightarrow \quad \tau = 0 \qquad (5.32)$$

$$\overline{X}_h = \frac{X_t}{2} + \frac{Y^c - Y_t}{4} \qquad (5.33)$$

$$X_t = K + \frac{Y^c - Y_t}{2} \qquad (5.34)$$

$$\overline{X}_f = X_t - \overline{X}_h = \frac{X_t}{2} - \frac{Y^c}{4} + \frac{Y_t}{4} \qquad (5.35)$$
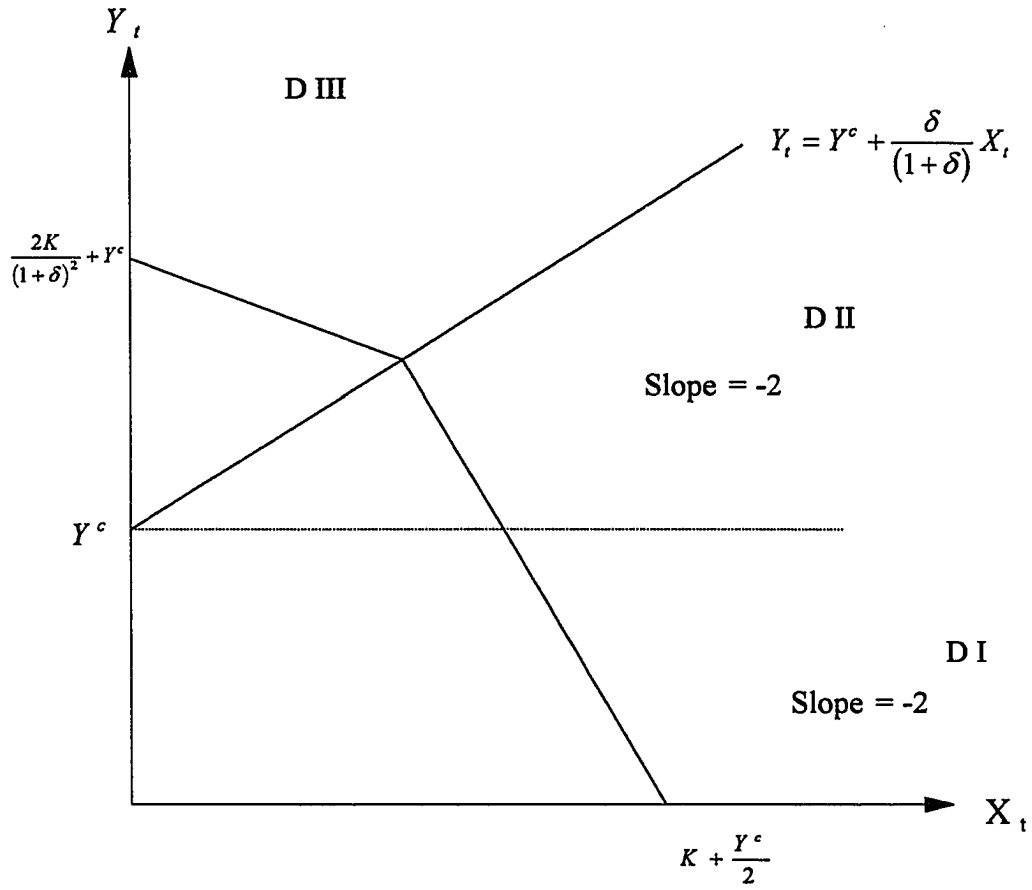
Figure IX : Foreign Firm's Stage I Best Response Function

Domain DII

$$Z < 0 \quad \Rightarrow \quad Y_t > Y^c \qquad (\text{ firm avoids dumping }) \tag{5.36}$$

$$Z < \frac{-\delta \beta X_t}{(1+\delta)} \quad \Rightarrow \quad Y_t < Y^c + \frac{\delta X_t}{(1+\delta)} \tag{5.37}$$

$$X_h = \overset{*}{X}_h \qquad \tau = 0 \tag{5.38}$$

$$X_h = \frac{Y^c - Y_t}{2} + \frac{X_t}{2} \tag{5.39}$$

$$X_t = K + Y^c - Y_t \tag{5.40}$$

$$\overline{X}_f = \frac{X_t}{2} - \frac{Y^c}{2} + \frac{Y_t}{2} \tag{5.41}$$

Domain DIII (dumping occurs and the firm pays dumping penalty)

$$Z < 0 \quad \Rightarrow \quad Y_t > Y^c \tag{5.42}$$

$$Z > \frac{-\delta \beta X_t}{(1+\delta)} \quad \Rightarrow \quad Y_t > Y^c + \frac{\delta X_t}{(1+\delta)} \tag{5.43}$$

$$\overline{X}_h = \frac{(2+\delta)}{4(1+\delta)} X_t + \frac{Y^c - Y_t}{4} \qquad \tau > 0 \tag{5.44}$$

$$X_t = \left(\frac{(1+\delta)}{4+4\delta-\delta^2} \right) \left\{ 4K + (2+\delta)(Y^c - Y_t) \right\}$$

(5.45)

$$X_f = \frac{(2+3\delta)X_t}{4(1+\delta)} - \frac{Y^c + Y_t}{4}$$

(5.46)

CHAPTER VI

HOME FIRM AND ANTIDUMPING LAW

The home firm's Stage II and Stage I problems analytically remain identical to the unconstrained case. Although the home firm's objective function does not depend on whether or not antidumping laws are present in the home country, its best response (the solution rule) is affected by the presence or absence of antidumping laws in the country. In all three domains, as defined earlier, the home firm's solution strategy is different because the foreign firm's sales in the home market are sensitive to the presence of the antidumping laws in the home country. When there is a penalty for dumping in the home country, the domestic firm has an incentive to expand its sales and force the foreign firm to cut back its sales in the home market or pay the dumping tariff and the home firm incorporates this response into its stage I solution rule. At stage I the home firm maximizes the following profit function with respect to Y_t.

$$\overset{*}{\pi}_h(Y_t, X_t) = (P_h - C)\overline{Y}_h(Y_t, X_t) - \eta(Y_t) + \lambda[Y_t - \overline{Y}_h(Y_t, X_t)] \tag{6.1}$$

The first order condition provides the home firm's best response function as given below.

$$\frac{\partial \overset{*}{\pi}_h}{\partial Y_t} = \left(\frac{\partial \overset{*}{\pi}_h}{\partial \overline{Y}_h} \times \frac{\partial \overline{Y}_h}{\partial Y_t}\right) + \left(\frac{\partial \overset{*}{\pi}_h}{\partial \lambda} \times \frac{\partial \lambda}{\partial Y_t}\right) + \left(\frac{\partial \overset{*}{\pi}_h}{\partial \overline{X}_h} \times \frac{\partial \overline{X}_h}{\partial \overline{Y}_h} \times \frac{\partial \overline{Y}_h}{\partial Y_t}\right) + \left(\frac{\partial \overset{*}{\pi}_h}{\partial Y_t}\right) = 0 \tag{6.2}$$

The first two terms of the first order condition vanish because of the complementary slackness condition and the rest can be written as:

$$\frac{\partial \overset{*}{\pi}_h}{\partial Y_t} = \left(\frac{\partial \overset{*}{\pi}_h}{\partial \overline{X}_h} \times \frac{\partial \overline{X}_h}{\partial \overline{Y}_h} \times \frac{\partial \overline{Y}_h}{\partial Y_t} \right) + \lambda - \eta = 0 \qquad (6.3)$$

We know that $\dfrac{\partial \pi_h}{\partial X_h} = -\beta Y_h$ and $\dfrac{\partial Y_h}{\partial Y_t} = 1$ and by substituting λ from chapter IV in to the above we get the following.

$$\frac{\partial \overset{*}{\pi}_h}{\partial Y_t} = -\beta Y_h \frac{\partial \overline{\overline{X}}_h}{\partial \overline{Y}_h} + A - \beta X_h - 2\beta Y_h - C - \eta = 0 \qquad (6.4)$$

From the previous chapters it can be shown that given

$$X_t, Y_t \quad s.t. \quad Y_t < Y^c \quad \Rightarrow \quad X_h = \frac{X_t}{2} + \frac{Y^c - Y_t}{4} \Rightarrow \frac{\partial X_h}{\partial Y_t} = -\frac{1}{4} \qquad (6.5)$$

$$X_t, Y_t \quad s.t. \quad Y_t \in \left(Y^c, Y^c + \frac{\delta X_t}{1+\delta} \right) \quad \Rightarrow \quad X_h = \frac{X_t + Y^c - Y_t}{2} \Rightarrow \frac{\partial X_h}{\partial Y_t} = -\frac{1}{2} \qquad (6.6)$$

$$X_t, Y_t \quad s.t. \quad Y_t > Y^c + \frac{\delta X_t}{1+\delta} \Rightarrow \quad \overline{X}_h = \frac{Y^c - Y_t}{4} + \frac{(2+\delta)}{4(1+\delta)} X_t \Rightarrow \frac{\partial \overline{X}_h}{\partial Y_t} = -\frac{1}{4} \quad . \quad (6.7)$$

It is clear that though X_h is continuous it is not everywhere differentiable, and that causes a non-concavity in the home firm's profit function, $\pi_h = [Y_t; X_h(Y_t)]$. This non-concavity in the home firm's profit function results in discontinuity in its stage I best response function which, thereby, may lead to the existence of multiple solutions in our model.

Unlike the unconstrained case, we cannot get the home firm's stage I best response function in one step here. In the presence of antidumping laws there are different solution rules in different domains for the home firm. Therefore, we have to construct the home firm's stage I best response function by putting together all the solution rules it uses in various domains. We define R_1 as the home firm's stage I solution rule in domain DI and similarly R_2 and R_3 are its solution rules in domains DII and DIII, respectively. These are given below.

$$\frac{\partial \pi_h}{\partial Y_t} = R_1 \qquad \text{where} \qquad Y_t < Y^c \qquad\qquad (6.8)$$

$$\frac{\partial \pi_h}{\partial Y_t} = R_2 \qquad \text{where} \qquad Y_t \in \left(Y^c, Y^c + \frac{\delta}{1+\delta} X_t \right) \qquad\qquad (6.9)$$

$$\frac{\partial \pi_h}{\partial Y_t} = R_3 \qquad \text{where} \qquad Y_t > Y^c + \frac{\delta}{1+\delta} X_t \qquad\qquad (6.10)$$

When appropriate values for $\overline{X}_h$ and $\frac{\partial \overline{X}_h}{\partial \overline{Y}_h}$ from domain DI, DII, and DIII are substituted into equation (6.4), we get the solution rules R_1, R_2, and R_3 in the following form.

$$R_1: \quad \frac{\partial \overset{*}{\pi}_h}{\partial Y_t} = \left[A - (C + \eta) + \frac{7}{4}\beta Y_t - \beta \left(\frac{X_t}{2} + \frac{Y^c - Y_t}{4} \right) \right] = 0 \qquad \text{or} \qquad (6.11)$$

$$R_1: \quad Y_t = \frac{2L}{3} - \frac{Y^c}{6} - \frac{X_t}{3} \qquad\qquad (6.12)$$

$$R_2: \quad \frac{\partial \overset{\bullet}{\pi}_h}{\partial Y_t} = \left[A - (C + \eta) - \frac{3}{2}\beta Y_t - \beta\left(\frac{X_t}{2} + \frac{Y^c - Y_t}{2} \right) \right] = 0 \qquad \text{or} \qquad (6.13)$$

$$R_2: \quad Y_t = L - \frac{Y^c}{2} - \frac{X_t}{2} \qquad\qquad (6.14)$$

$$R_3: \quad \frac{\partial \overset{\bullet}{\pi}_h}{\partial Y_t} = \left[A - (C + \eta) - \frac{7}{4}\beta Y_t - \beta\left(\frac{2 + \delta}{4(1 + \delta)} X_t + \frac{Y^c - Y_t}{4} \right) \right] = 0 \qquad \text{or} \qquad (6.15)$$

$$R_3: \quad Y_t = \frac{2L}{3} - \frac{Y^c}{6} - X_t\left[\frac{2 + \delta}{6(1 + \delta)} \right]. \qquad\qquad (6.16)$$

A point to emphasize here is that R_1, R_2, and R_3 are not true reaction functions, but a certain portion of each may be used by the home firm to find its best response in domains DI, DII, and DIII, respectively. Figure X depicts all three of the home firm's solution rules. A few important points on that diagram are defined as follows:

$$R_1 \text{ and } R_2 \text{ intersect at } (X_t, Y_t) = (\bar{X}, \bar{Y}) = \left[2(L - Y^c); \frac{Y^c}{2} \right] \qquad\qquad (6.17)$$

$$X_2 \quad as \quad X_t \quad s.t. \quad R_2[X_2; Y^c] = 0 \qquad\qquad (6.18)$$
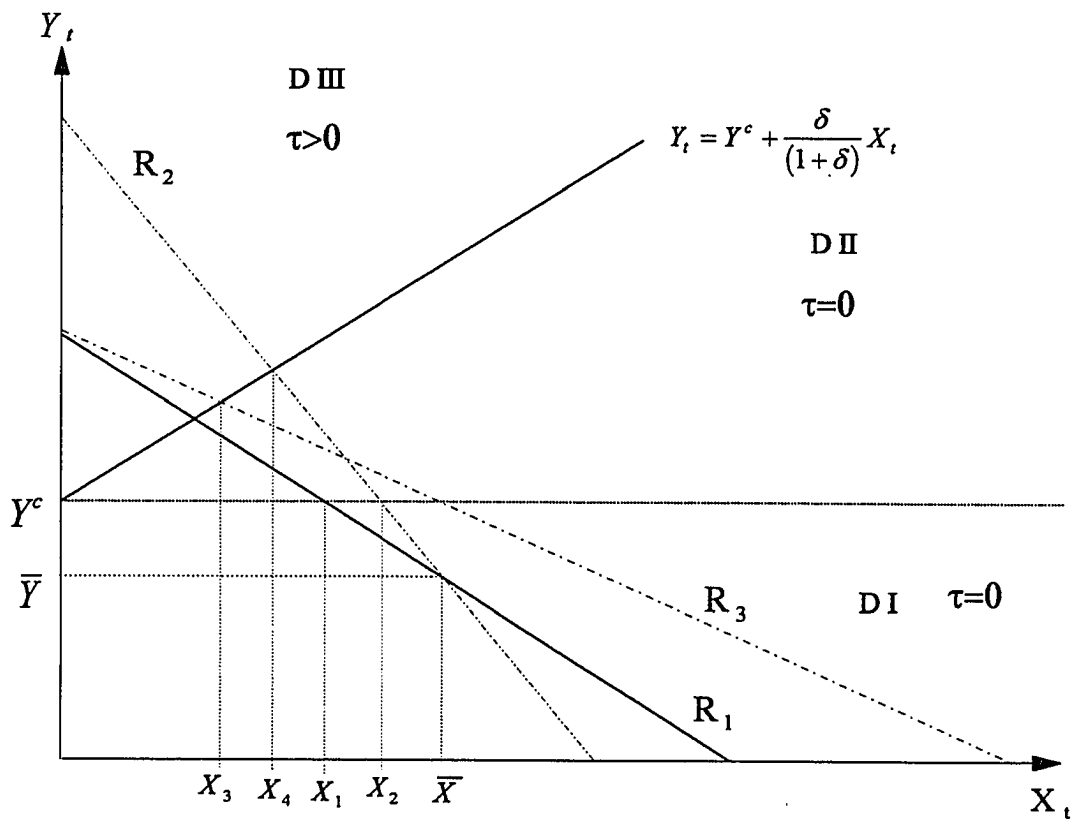
Figure X: Home Firm's Solution Rules

$$X_1 \quad as \quad X_t \quad s.t. \quad R_1\left[X_1;Y^c\right] = 0 \tag{6.19}$$

$$X_4 \quad as \quad X_t \quad s.t. \quad for \quad R_2, \quad Y^c - Y_t + \frac{\delta}{1+\delta}X_t = 0 \tag{6.20}$$

$$X_3 \quad as \quad X_t \quad s.t. \quad for \quad R_3, \quad Y^c - Y_t + \frac{\delta}{1+\delta}X_t = 0 \tag{6.21}$$

As we have shown that given $Y_t < Y^c$,

$$\frac{\partial \overset{\bullet}{\pi}_h}{\partial Y_t} = R_1 = \left[L - \frac{7}{4}Y_t - \frac{X_t}{2} - \left(\frac{Y^c - Y_t}{4}\right)\right] = ?, \tag{6.22}$$

and the limit of the function R_1 when Y_t approaches Y^c from below is:

$$\left.\frac{\partial \overset{\bullet}{\pi}_h}{\partial Y_t}\right|_{Y_t \to Y^{c-}} = R_1\big|_{Y_t \to Y^{c-}} = \left[L - \frac{7}{4}Y_t - \frac{X_t}{2}\right] = R_1\left(Y^c\right). \tag{6.23}$$

if $\quad X_t > X_1 = 2L - \frac{7}{2}Y^c$, then

the value of the above derivative is negative, so a local solution exists for $Y_t, Y_t < Y^c$ and therefore, R_1 is relevant.

if $\quad X_t < X_1 = 2L - \frac{7}{2}Y^c$, then the above derivative (6.23) would be positive and,

therefore, there is no solution for $Y_t, \overset{*}{Y_t} < Y^c$. This implies that the home firm's profits are

rising at this point, and therefore, its optimal response(Y^*) must be greater than Y^c and,

thus, we have a local solution $Y^* > Y^c$. We can summarize this in the following way.

$$R_1\big|_{Y_t = Y^c} > 0, \quad R_1\big|_{Y_t \to Y^{c-}} > 0 \quad \Rightarrow \quad \forall \; X_t \le X_1 \, , Y^* > Y^c \tag{6.24}$$

This means that if the foreign firm chooses any X_t which is less than X_1, then R_1 is not an

appropriate solution rule for the home firm. In this case either R_2 or R_3 or the boundary

would be a relevant solution rule for the home firm. Similarly, for

$$Y^c \in \left(Y^c, Y^c + \frac{\delta}{1+\delta} X_t \right),$$

$$\frac{\partial \overset{*}{\pi}_h}{\partial Y_t} = R_2 = \left[L - \frac{3}{2} Y_t - \frac{X_t}{2} - \left(\frac{Y^c - Y_t}{2} \right) \right] = ?, \tag{6.25}$$

$$\frac{\partial \overset{*}{\pi}_h}{\partial Y_t} \Bigg|_{Y_t \to Y^{c+}} = R_2\big|_{Y_t = Y^c} = \left[L - \frac{3}{2} Y_t - \frac{X_t}{2} \right] = ? \, , \text{ and} \tag{6.26}$$

if $\quad X_t > X_2 = 2L - 3Y^c$, then $\tag{6.27}$

$$\left. \frac{\partial \overset{\bullet}{\pi}_h}{\partial Y_t} \right|_{Y_t \to Y^{c+}} < 0 \qquad \Rightarrow \qquad \forall \ X_t > X_2, \overset{\bullet}{Y}_t < Y^c \qquad\qquad (6.28)$$

Likewise, if the foreign firm chooses any $X_t \geq X_2$, the appropriate solution rule for the home firm is R_1, and therefore, R_2, and R_3 are not relevant in this case, and there is a local solution $Y^* < Y^c$ for $X_t \geq X_2$.

If $\qquad X_t < X_2 = 2L - 3Y^c$,

$$\left. \frac{\partial \overset{\bullet}{\pi}_h}{\partial Y_t} \right|_{Y_t \to Y^{c+}} > 0 \qquad\qquad\qquad\qquad\qquad\qquad (6.29)$$

Therefore, a local solution for Y_t exists, $\overset{\bullet}{Y}_t > Y^c$, and there may be a local solution in DI, $Y^* < Y^c$. However, if

$$2L - 3.5Y^c = X_1 < X_t < X_2 = 2L - 3Y^c \qquad\qquad\qquad (6.30)$$

$$\left. \frac{\partial \overset{\bullet}{\pi}_h}{\partial Y_t} \right|_{Y_t \to Y^{c+}} > 0 \ \text{ and } \ \left. \frac{\partial \overset{\bullet}{\pi}_h}{\partial Y_t} \right|_{Y_t \to Y^{c-}} < 0 \qquad\qquad (6.31)$$

It is now clear that at $X_2, \pi_h(Y_t > Y^c) < \pi_h(Y_t \leq Y^c)$, and therefore, the home firm uses solution rule R_1 to find its best response to the foreign firm's $X_t \geq X_2$ and $Y^* < Y^c$. It is also true that at $X_1, \pi_h(Y_t > Y^c) > \pi_h(Y_t \leq Y^c)$ and the optimal response of the home

firm is $Y^* > Y^c$, and therefore, R_1 is not a relevant solution rule. However, we don't know which solution rule would be relevant for the home firm when the foreign firm chooses $X_t \in (X_1, X_2)$. We have two local solutions in this domain and same is true about points X_3 and X_4 (which we will analyze in detail in proceeding chapters).

At this stage we try to find multiple (two local) solutions when the foreign firm chooses $X_t \in (X_1, X_2)$ in order to find a unique solution rule (best response function) which can represent the home firm's behavior globally. For this we must explore situations that might exist where the home firm's profits with $Y_1 < Y^c$ (in DI)are identical to its profits with $Y_2 > Y^c$ (in DII). When we do so, it is found that:

$$\exists \quad \widetilde{X} \quad s.t. \quad \pi_h(R_1) = \pi_h(R_2)$$
and
$$\exists \quad X^j \quad s.t. \quad \pi_h(R_1) = \pi_h(B)$$
and

(6.32)[1]

$$\widetilde{X} \in [X_1; X_2]$$

(6.33)

$$X^j \in [X_3; X_4]$$

The implication here, is that the home firm is indifferent between $Y_1(\widetilde{X})$ and $Y_2(\widetilde{X})$ as the best response to the foreign firm's $X_t = \widetilde{X}$, and either $Y_1(X^j)$ or $B(X^j)$ would be its best choice when the foreign firm chooses $X_t = X^j$ and these cause discontinuities in the home firm's reaction function at these points. Therefore, we may have multiple solutions: X_t^1 (in DI), $\widetilde{X}$, and X_t^2 (in DII) or, similarly, X_t^1 (in DI), X^j, and X_t^B (at the boundary). All of the above can be summarized as follows:

---

[1]For detailed derivation see Appendix A, and B.

$X_t < X_3$ $\Rightarrow$ R_3 is the relevant solution rule. (6.34)

and solution is in DIII.

$X_1 > X_t > X_4$ $\Rightarrow$ no solution in R_3, R_2 is relevant. (6.35)

and solution will be in DII.

$X_t = \tilde{X}$ $\Rightarrow$ R_1 or R_2 is the solution rule (6.36)

and solution may be in DI or DII.

$X_3 < X_t < X_4$ $\Rightarrow$ Solution on the boundary of DII and DIII. (6.37)

$X_t < X_1$ $\Rightarrow$ optimal $Y_t > Y_t^c$ (6.38)

$X_t > X_2$ $\Rightarrow$ optimal $Y_t < Y_t^c$. (6.39)

When this information is combined with the solution rules for the home firm in three domains, we obtain a solution rule that represent the home firm's behavior globally and this provides a stage I best response function for this firm. One such best response function for the home firm, which shows only one jump (discontinuity) from DI to DII at $\tilde{X}$, is drawn in Figure XI .The reaction function is drawn in thick lines and the discontinuity in shown by a thick dashed line. Some important points, additional to those described on the previous figure, are explained below.
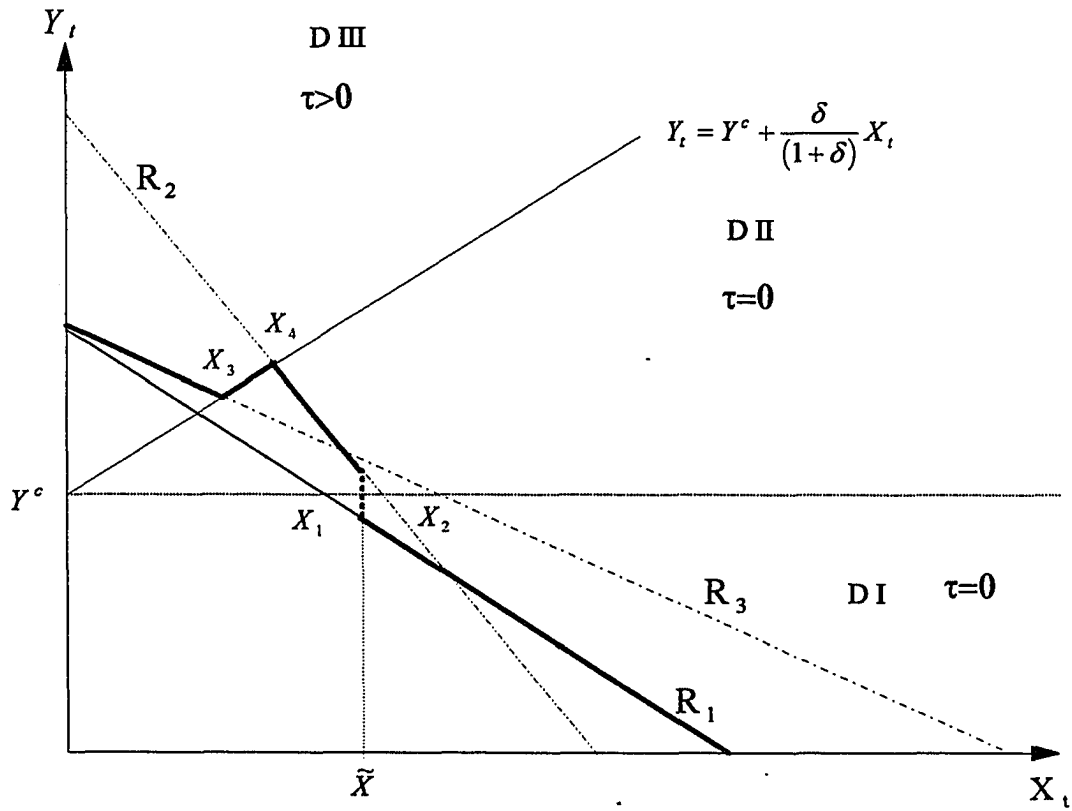
$$Y_t = Y^c + \frac{\delta}{(1+\delta)} X_t$$

D III

$\tau > 0$

R_2

X_4

X_3

D II

$\tau = 0$

Y^c

X_1

X_2

R_3

D I

$\tau = 0$

R_1

$\tilde{X}$

X_t

Y_t

Figure XI: Home Firm's Stage I Reaction Function

$$\tilde{X} \quad as \quad X_t \quad s.t. \quad R_1\left[\tilde{X};Y_1\right]=0 \tag{6.40}$$

$$\tilde{X} \quad as \quad X_t \quad s.t. \quad R_2\left[\tilde{X};Y_2\right]=0 \tag{6.41}$$

$$X^j \quad as \quad X_t \quad s.t. \quad R_1\left[X^j\right]=0 \tag{6.42}$$

$$X^j \quad as \quad X_t \quad s.t. \quad B\left[X^j\right]=0 \tag{6.43}$$

Where Y_1 is obtained by solving $R_1\left(\tilde{X},Y_1\right)$ and $Y_2:R_2\left(\tilde{X},Y_2\right)$. Given the above explanation and the diagram, it is clear that if:

$$X_t < X_3 \qquad \Rightarrow \qquad R_3 \text{ is the relevant solution rule.} \tag{6.44}$$

$$X_1 > X_t > X_4 \qquad \Rightarrow \qquad \text{no solution in } R_3, R_2 \text{ is relevant.} \tag{6.45}$$

$$X_t < X_1 \qquad \Rightarrow \qquad \text{optimal } Y_t > Y_t^c \tag{6.46}$$

$$X_t > X_2 \qquad \Rightarrow \qquad \text{optimal } Y_t < Y_t^c \tag{6.47}$$

The other possible reaction functions which depict a discontinuity from DI to the boundary and both a jumps from DI to II and DI to the boundary will be analyzed in the following chapters where we try to characterize the solution of this model.

CHAPTER VII

SOLUTION OF THE MODEL

The major portion of the rest of the dissertation will be devoted to outlining the solution (solutions) of our model. In the duopoly games, like our model, that are characterized by the best response functions, the solution is obtained where best responses of the two firms coincide or, graphically, where the best response curves of the two firms intersect. It has already been shown that best responses of home and foreign firms are, in the end, functions of the parameters of the model. Therefore, the solution to our model is predicated upon the values of these parameters which include demand and cost conditions in home and foreign countries and an antidumping tariff in the home country.

In the last chapter we derived a stage I best response function for the home firm. Given the best response curve in Figure VII, it was explained that if:

$X_t < X_3$ $\Rightarrow$ R_3 is the relevant solution rule

and the solution is in DIII.

$X_3 < X_t < X_4$ $\Rightarrow$ The solution is on the boundary of DII and DIII.

$X_1 > X_t > X_4$ $\Rightarrow$ no solution in R_3, R_2 is relevant

and the solution will be in DII.

$X_t < X_1$ $\Rightarrow$ optimal $Y_t > Y_t^c$

$X_t > X_2$ $\Rightarrow$ optimal $Y_t < Y_t^c$.

$X_t = \tilde{X}$ $\Rightarrow$ R_1 or R_2 is the solution rule

and the solution may be in DI or DII.

The above explains what solution rules the home firm would use in different domains. However the problem here is that all these domains are not fixed, they depend on the parameters of the model. Whenever there is a change in the values of the parameters, these domains would change too. The no-dumping and dumping regions are affected whenever the value of Y^c alters and, furthermore, within dumping region domains DII and DIII change with a change in the dumping penalty (the value of δ): as δ gets bigger, domain DII gets larger and domain DIII, where the foreign firm chooses to dump in the home country and pay antidumping tariff, shrinks. This also affects values of the variables X_3 and X_4 while X_1, X_2, and $\tilde{X}$ remain unchanged because they are independent of δ, as can be seen below.

$$X_1 = \frac{4L - 7Y^c}{2} \tag{7.1}$$

$$X_2 = \frac{4L - 6Y^c}{2} \tag{7.2}$$

$$\tilde{X} = 2L - 3.2248Y^c \tag{7.3}$$

$$X_3 = \left(\frac{1+\delta}{2+7\delta}\right)\left(4L - 7Y^c\right) \tag{7.4}$$

$$X_3(\delta = 0) = \left(\frac{4L - 7Y^c}{2}\right) = X_1 \tag{7.5}$$

$$X_3(\delta \to \infty) = \frac{1}{7}\left(\frac{4L - 7Y^c}{2}\right) \qquad (7.6)$$

$$X_4 = \left(\frac{1+\delta}{1+3\delta}\right)\left(\frac{4L - 6Y^c}{2}\right) \qquad (7.7)$$

$$X_4(\delta = 0) = \left(\frac{4L - 6Y^c}{2}\right) = X_2 \qquad (7.8)$$

$$X_4(\delta \to \infty) = \frac{1}{3}\left(\frac{4L - 6Y^c}{2}\right) \qquad (7.9)$$

The above variables, the relationship among them, and their dependence on δ are summarized in Figure XII along with the relevant domains. Since all these variables, and thereby the solution of our model depend on the values of the parameters, therefore, when we let the parameters of our model assume different values, the solution to the model changes. In order to handle this problem we may employ the following strategy. We divide the whole parameter space into two main subsets such that in one parameter space dumping will always take place in an unconstrained Nash equilibrium and, similarly, there may exist a parameter space where dumping, according to our definition of the model, will never occur. We examine these parameter spaces thoroughly as we move along, and define the restrictions on the parameters of the model under which these sub-spaces can be valid.

$$X_2 = \frac{4L - 6Y^c}{2}$$

$$\widetilde{X} = \frac{4L - 6.4496Y^c}{2}$$

$$X_1 = \frac{4K - 7Y^c}{2}$$

Solution in DI

Solution in DII

Solution on
the Boundary

X_4

Solution in DIII

X_3

δ

$\overset{*}{\delta}$
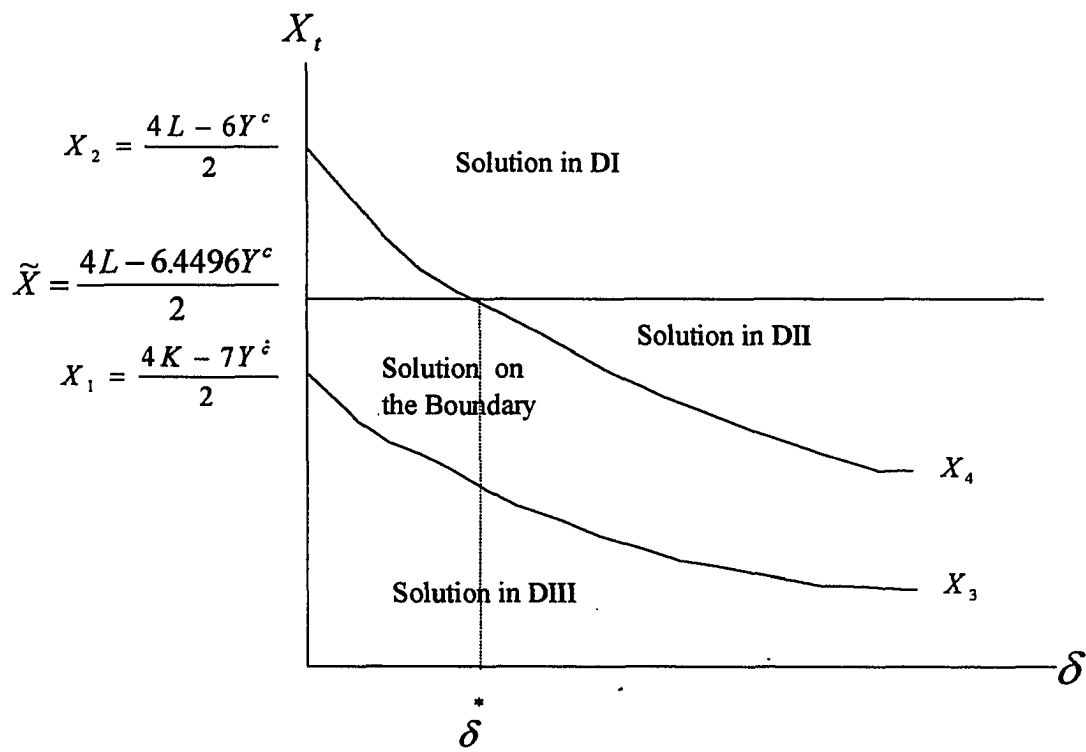
Figure XII : Solutions

Dumping Solution

We start with the assumption that, absent antidumping laws, if the foreign firm sells in both the home and foreign markets, the resulting Nash equilibrium is in domain D III, where dumping takes place. According to the specification we laid down in chapter IV, this implies being in the dumping region where the main restriction on the parameters is the following.

$$4L - 2K - 7Y^c = J > 0. \tag{7.10}$$

When written in terms of the parameters of the model the above restriction implies:

$$4\left(\frac{A-(C+\eta)}{\beta}\right) - 2\left(\frac{\alpha-(\overline{C}+\overline{\eta})}{\beta}\right) - 7\left(\frac{A-\alpha-t}{\beta}\right) > 0 \tag{7.11}$$

and if we assume identical cost conditions in both countries it reduces to the following.

$$5\alpha + 7t - 3A - 2(C+\eta) > 0 \tag{7.12}$$

From the earlier chapters we know that the home and foreign firms use the following solution strategies (solution rules) in this domain (DIII).

$$L - \frac{Y^c}{4} - \frac{3Y_t}{2} - \frac{(2+\delta)}{4(1+\delta)}X_t = 0 \tag{7.13}$$

and

$$K + \left(\frac{2+\delta}{4}\right)(Y^c - Y_t) - \frac{\left(4 + 4\delta - \delta^2\right)}{4(1+\delta)} X_t = 0 \qquad (7.14)$$

We solve the above two equations simultaneously using Cramer's Rule and get the Nash solution for stage I variables in this domain (Y_t^3, X_t^3) as follows.

$$\begin{bmatrix} \dfrac{3}{2} & \dfrac{(2+\delta)}{4(1+\delta)} \\[2ex] \dfrac{2+\delta}{4} & (1-S) \end{bmatrix} \begin{bmatrix} Y_t \\[2ex] X_t \end{bmatrix} = \begin{bmatrix} L - \dfrac{Y^c}{4} \\[2ex] K + \dfrac{(2+\delta)}{4} Y^c \end{bmatrix} \qquad (7.15)$$

We group some terms and define

$$S = \frac{\delta^2}{4(1+\delta)} \quad \text{and} \quad m = \left(\frac{1 + \delta/2}{1+\delta}\right) \qquad (7.16)$$

therefore,

$$\begin{bmatrix} Y_t^3 \\[2ex] X_t^3 \end{bmatrix} = \frac{1}{D} \begin{bmatrix} (1-S) & -\dfrac{(2+\delta)}{4(1+\delta)} \\[2ex] -\dfrac{(2+\delta)}{4} & \dfrac{3}{2} \end{bmatrix} \begin{bmatrix} L - \dfrac{Y^c}{4} \\[2ex] K + \left(\dfrac{2+\delta}{4}\right) Y^c \end{bmatrix} \qquad (7.17)$$

where D is calculated as below.

$$D = \frac{3(1-S)}{2} - \frac{(2+\delta)^2}{16(1+\delta)} = \frac{24(1-S)(1+\delta)-(2+\delta)^2}{16(1+\delta)}$$

(7.18)

$$= \left\{ \frac{4(1+\delta)}{4(1+\delta)} \right\} \left\{ \frac{6(1-S)-(1+S)}{4} \right\} = \frac{5-7S}{4}$$

Hence, after simplification, the Nash solution in this domain is:

$$Y_t^3 = \frac{4(1-S)L - 2Y^c - 2mK}{5-7S}$$

(7.19)

and

$$X_t^3 = \frac{6K + \frac{7}{2}\left(1+\frac{\delta}{2}\right)Y^c - 2\left(1+\frac{\delta}{2}\right)L}{5-7S}$$

(7.20)

In the absence of an antidumping law in the home country $\delta = 0 \Rightarrow S = 0 \Rightarrow m = 1$, therefore,

$$Y_t^3(\delta = 0) = \frac{4L - 2Y^c - 2K}{5} \qquad \text{and} \qquad$$

(7.21)

$$X_t^3(\delta = 0) = \frac{6K + \frac{7}{2}Y^c - 2L}{5}$$

(7.22)

What we need to check at this stage is whether this Nash solution is consistent with the restrictions to be in the domain DIII. One of these restrictions, in this case, is that the solution should be such that dumping always takes place, i.e., in equilibrium Y_t must be greater than the threshold level Y^c. Absent any antidumping tariff this means that $Y_t^3(\delta = 0) > Y^c$.

$$Y_t^3(\delta = 0) - Y^c = \frac{4L - 2Y^c - 2K}{5} - Y^c = ? \tag{7.23}$$

$$= 4L - 2K - 7Y^c > 0 \tag{7.24}$$

This satisfies the restriction because to begin with we assumed $4L - 2K - 7Y^c > 0$ for the solution to be in domain DIII. In this case, the antidumping laws are present and the dumping tariff is imposed, the equilibrium Y_t being in DIII implies that Y_t must be greater than Y_t at the boundary of DII and DIII, i.e., $Y_t^3 > Y_t^B$.

$$Y_t^B = Y^c + \left(\frac{\delta}{1+\delta}\right) X_t \tag{7.25}$$

$$Y_t^3 - Y_t^B = \frac{4(1-S)L - 2Y^c - 2mK}{5 - 7S} - Y^c - \left(\frac{\delta}{1+\delta}\right)\left\{\frac{6K + \frac{7}{2}\left(1 + \frac{\delta}{2}\right)Y^c - 2\left(1 + \frac{\delta}{2}\right)L}{5 - 7S}\right\}$$

$$4L\left(\frac{4 + 6\delta}{20 + 20\delta - 7\delta^2}\right) - 4K\left(\frac{2 + 7\delta}{20 + 20\delta - 7\delta^2}\right) - Y^c\left(\frac{28 + 42\delta}{20 + 20\delta - 7\delta^2}\right) > 0$$

$$4L - 2K\left(\frac{2+7\delta}{2+3\delta}\right) - 7Y^c > 0 \qquad (7.26)$$

We can find the bound on δ that maintains the inequality in equation (7.26) to ensure the solution in domain DIII. We also find further restrictions on the parameters of our model so that dumping takes place in equilibrium. In order to do so we further group some terms. Let

$$\varpi = \frac{4L - 7Y^c}{2K} \qquad (7.27)$$

and being in dumping domain implies that $\varpi = \dfrac{4L - 7Y^c}{2K} > 1$. Now we can write equation (7.26) as follows:

$$\varpi - \left(\frac{2+7\delta}{2+3\delta}\right) > 0 ? \qquad (7.28)$$

$$\lim_{\delta \to \infty}\left[\varpi - \left(\frac{2+7\delta}{2+3\delta}\right)\right] = \varpi - \frac{7}{3} \qquad (7.29)$$

Therefore, if $\varpi > \dfrac{7}{3}$, $\forall \delta$ we have a unique solution in DIII. But what if $\varpi < \dfrac{7}{3}$?

$$\frac{7}{3} > \varpi > 1 \quad \Rightarrow \quad \exists \quad \tilde{\delta} \quad s.t \quad \delta < \tilde{\delta}, \text{ solution is in DIII} \qquad (7.30)$$

$$\tilde{\delta} : \quad \varpi - \left(\frac{2+7\delta}{2+3\delta}\right) = 0 \qquad (7.31)$$

$$\widetilde{\delta} = \frac{2(\varpi - 1)}{(7 - 3\varpi)} \tag{7.32}$$

This further tightens the bounds on the parameters for the solution to be in domain DIII. This implies that if the antidumping penalty (δ) is greater than $\widetilde{\delta}$ then the solution is either on the Boundary (boundary of DII and DIII) Figure XIII, where the sales are
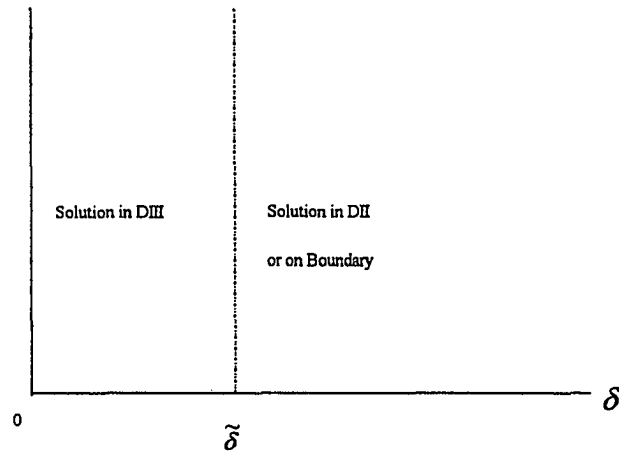
Figure XIII

chosen such that the price in the foreign country plus transportation cost are exactly equal to the price in the home country, or in domain DII, where the foreign firm always keep the price in the foreign market, inclusive of transportation costs, lower than the home market price, and avoids any antidumping charges against it.

Furthermore, in order to ensure the solution to be in domain DIII where dumping takes place in equilibrium, following restriction should also be fulfilled.

If $\varpi > \left(\dfrac{2+7\delta}{2+3\delta}\right)$, we always have a unique interior solution in domain DIII no matter what the size of the dumping penalty (δ) may be. Otherwise, we need the following restrictions on the parameter values of the model in order for the solution to be in DIII.

i. $\quad \varpi > 1 \quad \Rightarrow \quad \dfrac{4L-7Y^c}{2K} > 1 \quad \Rightarrow \quad 4L-2K-7Y^c > 0$ $\qquad$ (7.33)

ii. $\quad \varpi < \dfrac{7}{3} \quad \Rightarrow \quad 14K+21Y^c - 12L > 0$ $\qquad$ (7.34)

iii. $\quad \delta < \widetilde{\delta} = \dfrac{2(\varpi-1)}{(7-3\varpi)} = \dfrac{2\left(4L-2K-7Y^c\right)}{14K+21Y^c-12L}$ $\qquad$ (7.35)

In the presence of antidumping laws, other possible equilibria may be on the boundary of DII and DIII or in domain DII. Now we find the subset of the parameter space in which the solution to the stage I game is on the boundary of domain DII and DIII. The solution rule for the home firm, in this case, is the equation for the line which defines the boundary of domain DII and DIII, which is as follows:

$$Y_t - Y^c - \left(\dfrac{\delta}{1+\delta}\right)X_t = 0 \qquad (7.36)$$

and the solution rule for the foreign firm is:

$$\left(\dfrac{2+\delta}{4}\right)\!\left(Y_t - Y^c\right) + (1+S)X_t = 0 \qquad (7.37)$$

Solving equations (7.36) and (7.37) simultaneously, we get the following solution for the foreign and home firm, respectively.

$$X_t^B = \frac{2(1+\delta)}{2+3\delta} K \tag{7.38}$$

$$Y_t^B = Y^c + 2K\left(\frac{\delta}{2+3\delta}\right) \tag{7.39}$$

By construction, Y_t^B is on the boundary of domain DII and DIII, but for X_t^B to be a valid solution, it has to fulfill the condition that $X_3 < X_t^B < X_4$. Where X_3 and X_4 are as defined earlier, they are obtained, respectively, by solving the home firm's solution rules for domain DIII and DII simultaneously with the equation for the boundary.

$$X_3 = \left(\frac{1+\delta}{2+7\delta}\right)(4L - 7Y^c) \tag{7.40}$$

$$X_4 = \left(\frac{1+\delta}{1+3\delta}\right)(2L - 3Y^c) \tag{7.41}$$

$$X_t^B - X_3 > 0 \quad \Rightarrow \quad 2K(2+7\delta) - (2+3\delta)(4L - 7Y^c) > 0 \tag{7.42}$$

$$X_t^B - X_3 > 0 \quad \Rightarrow \quad \varpi < \left(\frac{(2+7\delta)}{(2+3\delta)}\right) \tag{7.43}$$

$$X_4 - X_t^B > 0 \quad \Rightarrow \quad 4L - 6Y^c - 4K\left(\frac{1+3\delta}{2+3\delta}\right) > 0 \tag{7.44}$$

$$X_4 - X_t^B > 0 \quad \Rightarrow \quad \varpi > 2\left(\frac{1+3\delta}{2+3\delta}\right) - \frac{Y^c}{2K} \qquad (7.45)$$

For further facilitation, we define:

$$\sigma \equiv \frac{Y^c}{2K} \qquad (7.46)$$

The bound on δ from equation (7.45) further tightens the bound on the parameter space as follows:

$$\hat{\delta} = \frac{2(\varpi - 1 + \sigma)}{3(2 - \sigma - \varpi)} \qquad (7.47)$$

and when $\tilde{\delta}$ and $\hat{\delta}$ are compared, it is found that $\hat{\delta} > \tilde{\delta}$. Therefore, in terms of δ, the equilibrium is on the boundary if $\tilde{\delta} < \delta < \hat{\delta}$. In order for a unique equilibrium to take place on the boundary of domains DII and DIII, the constraint on the parameter values which are implied from equations (7.43) and (7.45) must hold and are given below.

$$\left(\frac{2+6\delta}{2+3\delta}\right) - \sigma < \varpi < \left(\frac{(2+7\delta)}{(2+3\delta)}\right) \qquad (7.48)$$

Now we try to find conditions under which the Nash equilibrium at stage I of the game occurs in domain DII where the solution rules for the home firm and the foreign firm are given below, respectively.

$$Y_t = L - \left(\frac{X_t + Y^c}{2}\right) \tag{7.49}$$

and

$$X_t = K + \left(\frac{Y^c - Y_t}{2}\right) \tag{7.50}$$

Solving these equations, (7.49) and (7.50), by the Cramer's rule, we get the solution values for the stage I variables as follows:

$$X_t^2 = \frac{4K + 3Y^c - 2L}{3} = \frac{4 - \varpi - \sigma}{6} \tag{7.51}$$

and

$$Y_t^2 = \frac{4L - 2K - 3Y^c}{3} = \frac{\varpi - 1 + 4\sigma}{3} \tag{7.52}$$

For the above solution to be valid, the resulting solution must be in domain DII, which implies $Y_t^2 > Y^c$ and $X_t^2 > X_4$.

$$Y_t^2 - Y^c > 0 \quad \Rightarrow \quad (\omega - 1) + \sigma > 0 \tag{7.53}$$

$$X_t^2 - X_4 > 0 \quad \Rightarrow \quad \left(\frac{4K + 3Y^c - 2L}{3}\right) - \left(\frac{1 + \delta}{1 + 3\delta}\right)\left(\frac{4L - 6Y^c}{2}\right) > 0 \tag{7.54}$$

$$X_t^2 - X_4 > 0 \quad \Rightarrow \quad \omega < \left(\frac{2 + 6\delta}{2 + 3\delta}\right) - \sigma \tag{7.55}$$

Therefore, a valid interior solution in domain DII requires the following restriction on the parameter values of the model.

$$1 - \sigma < \omega < \left(\frac{2 + 6\delta}{2 + 3\delta} \right) - \sigma \qquad (7.56)$$

and if we assume that $\varpi > 1$ then we have a unique equilibrium in domain DII as long as:

$$1 < \omega < \left(\frac{2 + 6\delta}{2 + 3\delta} \right) - \sigma \qquad (7.57)$$

Similarly, we define the restrictions on the parameter values, which are necessary to meet the solution of the model to occur in domain DI, where the home firm follows $4L - Y^c - 6Y_t - 2X_t = 0$ rule and the foreign firm uses $2K + Y^c - Y_t - 2X_t = 0$ rule to find the solution of the game. These solution rules, when solved simultaneously, yield the following solution for domain DI.

$$X_t^1 = \frac{12K + 7Y^c - 4L}{10} \qquad (7.58)$$

$$Y_t^1 = \frac{8L - 4Y^c - 4K}{10} \qquad (7.59)$$

Validity of these solutions also depends upon whether or not certain restrictions are met. One of these restrictions is that the solution value Y_t^1 has to be less than Y^c, and the other condition for the solution to be in DI is that X_t^1 must be greater than $\widetilde{X}$ when $\widetilde{X} > X_4$ or X_t^1 is greater than $\widetilde{X}_B$ when $\widetilde{X} < X_4$. Y^c and X_4 have already been defined

whereas $\tilde{X}$ is a point at which the home firm's best response function jumps from domain DI (solution rule R_1) to domain DII (to solution rule R_2). Similarly, $\tilde{X}_B$ is a point where this jump occurs from DI to the boundary of DII and DIII. We derive $\tilde{X}$ in Appendix B which is independent of δ and is equal to $2L - 3.2248Y^c = K(\omega + 0.55\sigma)$. This implies that $\tilde{X}$ falls between X_1 and X_2, i.e., $X_2 > \tilde{X} > X_1$.

$$Y_t^1 - Y^c < 0 \quad \Rightarrow \quad \varpi < 1 \tag{7.60}$$

$$X_t^1 > \tilde{X} > 0 \quad \Rightarrow \quad \left(\frac{12K + 7Y^c - 4L}{10}\right) - K(\varpi + 0.55\sigma) > 0 \tag{7.61}$$

$$\Rightarrow \quad \varpi < 1 - 0.23\sigma \tag{7.62}$$

$$\tilde{X} > X_4 \quad \Rightarrow \quad K(\varpi + 0.55\sigma) - K(\varpi + \sigma)\left(\frac{1+\delta}{1+3\delta}\right) > 0 \tag{7.63}$$

$$\Rightarrow \quad \varpi > \frac{\sigma(0.45 - 0.65\delta)}{2\delta} \tag{7.64}$$

At this stage it would be appropriate to summarize the results of this section by showing equilibrium in each domain along with the corresponding parameter space.

$$\text{Given } \varpi \equiv \frac{4L - 7Y^c}{2K} \qquad \text{and} \qquad \sigma \equiv \frac{Y^c}{2K}$$

$$\text{If} \quad \varpi > \left(\frac{2+7\delta}{2+3\delta}\right) > 1, \qquad\qquad \text{Solution in DIII} \tag{7.65}$$

If $\quad \left(\dfrac{2+6\delta}{2+3\delta}\right)-\sigma < \varpi < \left(\dfrac{(2+7\delta)}{(2+3\delta)}\right)$ $\qquad$ Solution on boundary (7.66)

If $\quad 1-\sigma < \omega < \left(\dfrac{2+6\delta}{2+3\delta}\right)-\sigma$ $\qquad$ Solution in DIII $\qquad$ (7.67)

If $\quad \varpi < 1$ $\qquad$ Solution in DI $\qquad$ (7.68)

Therefore, given $\varpi > 1$, we have unique solution:

in DIII if $\qquad \varpi > \left(\dfrac{2+7\delta}{2+3\delta}\right)$ $\qquad$ (7.69)

on Boundary if $\qquad \left(\dfrac{2+6\delta}{2+3\delta}\right)-\sigma < \varpi < \left(\dfrac{(2+7\delta)}{(2+3\delta)}\right)$ $\qquad$ (7.70)

in DII if $\qquad 1 < \omega < \left(\dfrac{2+6\delta}{2+3\delta}\right)-\sigma$ $\qquad$ (7.71)

NO-DUMPING SOLUTION

We have seen above that the parameter space in which we have no dumping solution, i.e., when parameter values are such that $\varpi < 1$, the foreign and home firms' best response curves intersect in domain DI. One possible situation is where the home and foreign firms' best response curves intersect only in DI and this can happen if the foreign firm's best response curve remains above the home firm's reaction curve in domains DII and DIII. A restriction that ensures this possibility is: $X_5 > X_2$, or equivalently $Y^F(X_2) > Y^c$, where X_2 is obtained by evaluating the home firm's solution rule R_2 at Y^c

and X_5 and $Y^F(X_2)$ are obtained by solving the foreign firm's solution rule at Y^c and X_2, respectively.

$$X_5 > X_2 \qquad \Rightarrow \qquad \varpi < 1 - \sigma \qquad \text{(unique solution in DI)}.$$

Rather interesting situations in our model are those when possibilities of multiple solutions emerge, i.e., when the foreign firm's reaction curve intersects the home firm's reaction curve in DI and either in DII or on the boundary. Now we explore the conditions under which multiple solutions may occur in domains DI and DII or in domain DI and on the boundary. One of restrictions to ensure intersections of the home and the foreign firms' best response curves in DII is that $X_t^2 > X_4$, where X_4 is as defined earlier and X_t^2 is the solution value of X_t in domain DII. It means that if $X_t^2 < X_4$, solution never takes place in DII, but it may take place on the boundary of DII and DIII, and in terms of restriction on the parameter values:

$$X_t^2 < X_4 \qquad \leftrightarrow \qquad \varpi + \sigma > \left(\frac{2+6\delta}{2+3\delta}\right)$$

This implies that if $\varpi + \sigma > 2, \left(\lim_{\delta \to \infty}\left(\frac{2+6\delta}{2+3\delta}\right) = 2\right)$, there is no solution in DII. However, if $\varpi + \sigma < 2$, a solution in domain DII is also possible along with solution in DI. These results are graphically represented in Figure XIV. Solution in DII possible if, given $\varpi + \sigma < 2$:
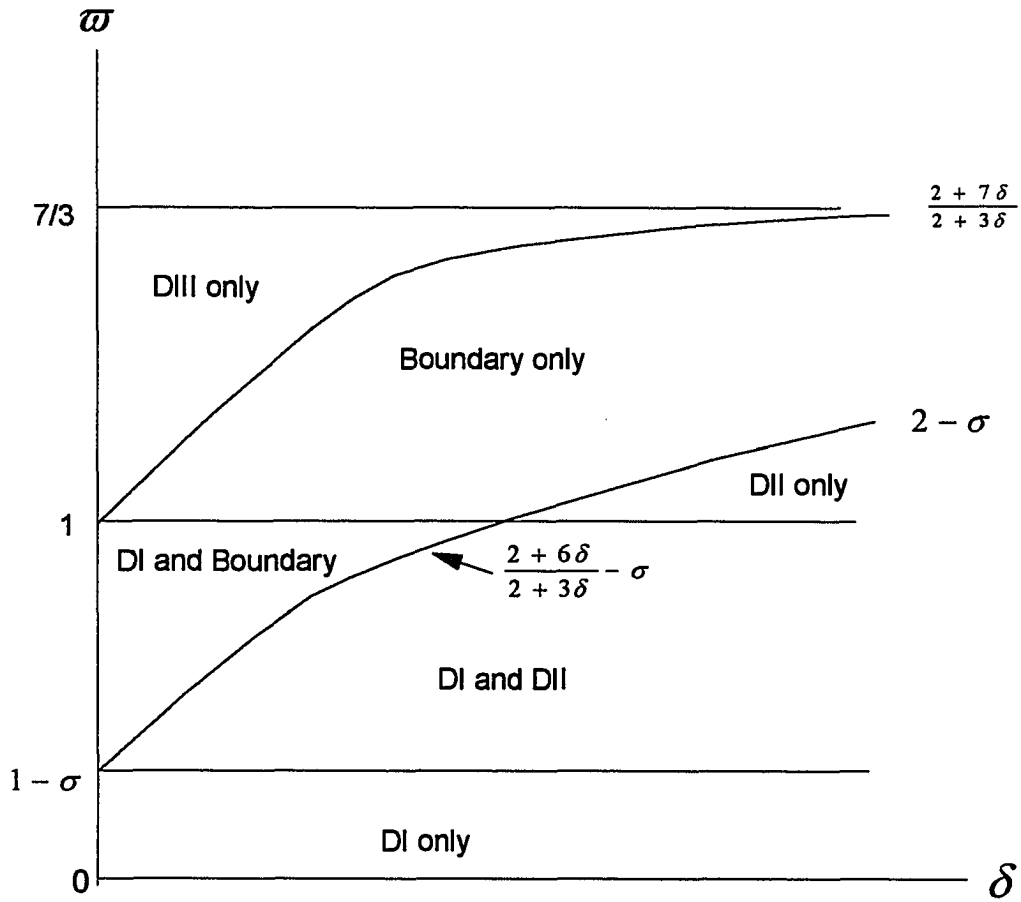
Figure XIV: Solution of the Model

$$X_t^2 > X_4 \qquad \Rightarrow \qquad \delta > \breve{\delta} = \frac{2}{3}\left(\frac{\varpi + \sigma - 1}{2 - \varpi - \sigma}\right) \tag{7.72}$$

Therefore, intersection of foreign and home firms' best response curves in domain DII is possible only if:

$$1 > \varpi + \sigma < 2; \quad \delta > \frac{2}{3}\left(\frac{\varpi + \sigma - 1}{2 - \varpi - \sigma}\right) \tag{7.73}$$

We have already discussed in the previous chapters that there is a possible jump in the home firm's best response curve either from R_1 to the boundary or from R_1 to R_2. The jump from R_1 to R_2 occurs at $X_t = \widetilde{X} = 2L - 3.2248Y^c = (\varpi + 0.55\sigma)K$, and given this, the solution of the model would be as follows:

If $\quad X_1 < \widetilde{X} < X_4$ Solution in DI only $\qquad$ (7.74)

If $\quad \widetilde{X} > X_4 \qquad$ but $\quad X_t^2 > \widetilde{X} \quad$ Solution in DI only $\qquad$ (7.75)

If $\quad X_t^2 < \widetilde{X} < X_t^1 \qquad$ Solutions in DI, DII, and $\widetilde{X}$ (7.76)

If $\quad \widetilde{X} > X_t^1 \qquad\qquad\qquad$ Solution in DII only $\qquad$ (7.77)

We know that $\widetilde{X} > X_1$ and now we check when $X_4 < \widetilde{X}$:

$$\left(\widetilde{X} - X_4\right) = \left(2L - 3.2248Y^c\right) - \left(2L - 3Y^c\right)\frac{1 + \delta}{1 + 3\delta} \tag{7.78}$$

$$\left. \left(\widetilde{X} - X_4 \right) \right|_{\delta=0} < 0 \tag{7.79}$$

$$\left(\widetilde{X} - X_4 \right) > 0 \quad if \quad \delta > \overset{*}{\delta} = \frac{0.2248 Y^c}{4L - 6.6734 Y^c} = \frac{0.1124\sigma}{\varpi + 0.1633\sigma} \tag{7.80}$$

$$\widetilde{X} - X_t^2 = \left(2L - 3.3348 Y^c \right) - \left(\frac{4K - 2L + 3Y^c}{3} \right) \tag{7.81}$$

$$\widetilde{X} - X_t^2 > 0 \quad \Rightarrow \quad \left(\varpi - 1 + 0.6628\sigma \right) > 0 \tag{7.82}$$

$$X_t^1 - \widetilde{X} = \left(\frac{12K - 4L + 7Y^c}{10} \right) - \left(2L - 3.3348 Y^c \right) \tag{7.83}$$

$$X_t^1 - \widetilde{X} > 0 \quad \Rightarrow \quad \left(1 - \varpi - 0.46\sigma \right) > 0 \tag{7.84}$$

The results of the above section are depicted by Figure XV and also summarized as follows:

$$\text{Given} \quad 1 < \varpi + \sigma < 2; \quad \delta > \frac{2}{3} \left(\frac{\varpi + \sigma - 1}{2 - \varpi - \sigma} \right), \tag{7.85}$$

$$if \quad \varpi < 1 - 0.66\sigma \quad \Rightarrow \qquad\qquad \text{solution in DI only.} \tag{7.86}$$

$$if \quad 1 - 0.46\sigma > \varpi > 1 - 0.66\sigma \quad \Rightarrow \quad \text{solution in DI, DII, and } \widetilde{X}. \tag{7.87}$$

$$if \quad \max(1, 2 - \sigma) > \varpi > 1 - 0.46\sigma \quad \text{and} \quad \delta > \breve{\delta} \Rightarrow \quad \text{solution in DII only.} \tag{7.88}$$
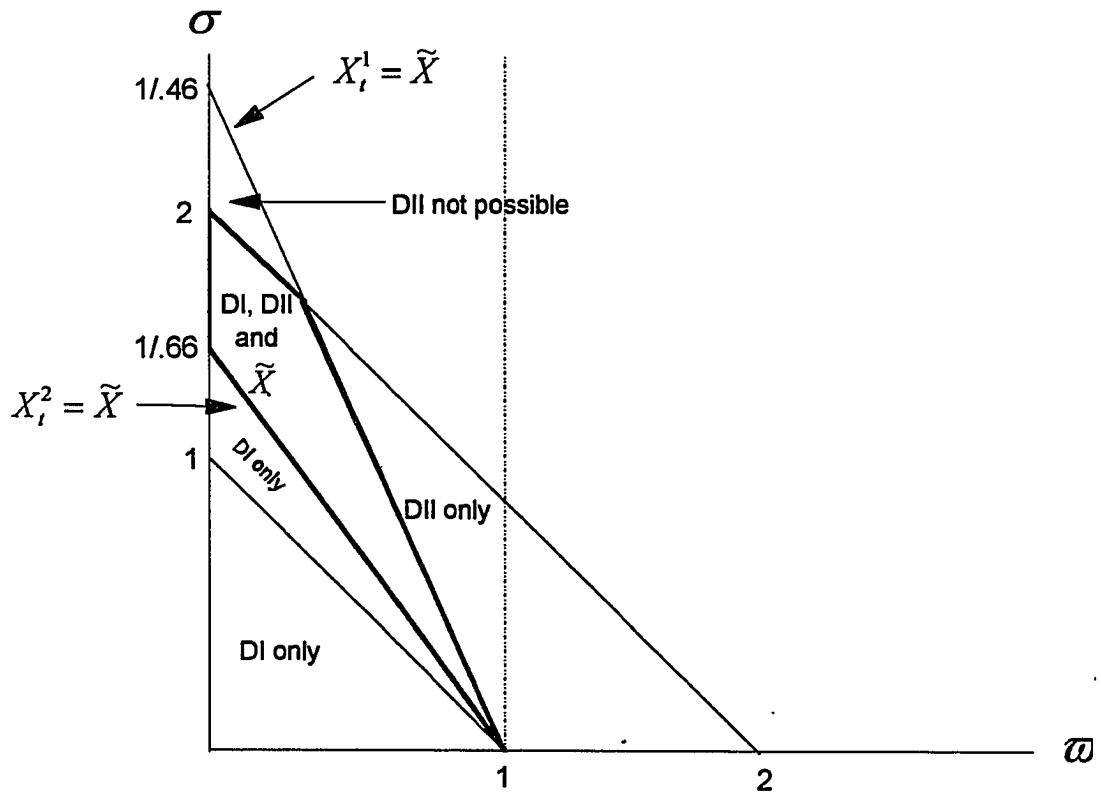
Figure XV : Multiple Solutions

Where $\breve{\delta}$ in defined in equation (7.72).

Similarly multiple solutions may also occur on DI, boundary, and on the jump from DI to the boundary. As we have shown, it is possible for solution to take place on the boundary under the following restrictions on the parameter values:

$$\varpi < 1 \text{ and } \varpi + \sigma > 2 \qquad (7.89)$$

or

$$\varpi < 1, \ \varpi + \sigma < 2, \text{ and } \delta > \frac{2}{3}\left(\frac{\varpi + \sigma - 1}{2 - \varpi - \sigma}\right) \qquad (7.90)$$

Like the previous case, we have different solution under different conditions:

$$\text{if} \qquad \widetilde{X} > X_t^1 \qquad \Rightarrow \qquad \text{solution on B only.} \qquad (7.91)$$

$$\widetilde{X} > X_t^1 \qquad \Rightarrow \qquad \varpi + 0.46\sigma > 1$$

$$\text{if} \qquad X_t^1 > \widetilde{X} > X_4 \quad \Rightarrow \qquad \text{solution on B, } \widetilde{X}, \text{ and DI} \qquad (7.92)$$

$$X_t^1 > \widetilde{X} > X_4 \quad \Rightarrow \quad \begin{cases} \varpi + 0.46\sigma < 1 \\ 2\delta\varpi > \sigma(0.45 - 0.65\delta) \end{cases} \qquad (7.93)$$

$$\text{if} \qquad \widetilde{X} < X_4, \widetilde{X} < X_t^1 \qquad (7.94)$$

In this case we have to determine which solution dominates, i.e., where the home firm's profits are greater. Therefore,

Solution in DI if
$$\pi_h\left(X_t^B, Y_t^B\right) < \pi_h\left(X_t^B, Y_t^I\left(X_t^B\right)\right) \qquad (7.95)$$

Solution in DI, $\tilde{X}$, and boundary if
$$\pi_h\left(X_t^B, Y_t^B\right) > \pi_h\left(X_t^B, Y_t^I\left(X_t^B\right)\right) \qquad (7.96)$$

X_t^B and Y_t^B are the solution values on the boundary whereas, $Y_t^I\left(X_t^B\right)$ is the value of Y_t obtained by using R_1 solution rule with X_t^B.

The implications of the above results are that for the parameter values such that $\varpi < 1$, absent antidumping laws or when ($\delta=0$), we have an equilibrium where dumping does not take place. Intuitively, the dumping laws should not matter if enforced in such circumstances. However, the above situation suggests that as antidumping laws become available or as penalty for dumping becomes more stringent (δ is increased)), multiple solutions may emerge some of which would be in domains where antidumping laws bite and consequently affect decisions made by both firms.

CHAPTER VIII

WELFARE ANALYSIS

In this chapter we analyze the welfare consequences of antidumping tariff in the home country because in our model antidumping laws are enforced by the home country alone. The total welfare of the home country depends on:

(i)   the net benefit from production and consumption of this good which is area under the home market demand curve bounded by the total quantity consumed is this market less the cost of producing the home firm's output.

$$\int_0^{Y_h+X_h} P_h(Y_h + X_h)d(Y_h + X_h) - cY_h \tag{8.1}$$

(ii)   The net trade effect which, in this case, is tariff revenues collected by the home government less the revenues accruing to the foreign firm which the firm repatriates to the foreign country.

$$\delta(P_f + t - P_h)X_h - P_h X_h = -X_h\big(P_h(1+\delta) - \delta(P_f + t)\big) \tag{8.2}$$

Therefore, the home country's total welfare (W) may be expressed as follows:

$$W = \int_0^{Y_h+X_h} P_h(Y_h + X_h)d(Y_h + X_h) - cY_h - P_h X_h + \delta(P_f + t - P_h)X_h \tag{8.3}$$

If we are in a domain where dumping takes place in equilibrium, then all the variables affecting the home country's welfare (X_d, Y_h, P_h, and P_f), in their reduced form, are functions of dumping penalty rate (δ). In this domain imposition of antidumping tariff or increase in change in the dumping penalty rate (δ) affects the home country's welfare as follows:

$$\frac{\partial W}{\partial \delta} = P_h\left(\frac{\partial(Y_h + X_h)}{\partial \delta}\right) + P_h'\left(\frac{\partial(Y_h + X_h)}{\partial \delta}\right) - c\frac{\partial Y_h}{\partial \delta} - P_h\frac{\partial X_h}{\partial \delta} - X_h P_h'\frac{\partial(Y_h + X_h)}{\partial \delta} + \left(P_f + t - P_h\right)X_h$$

$$+\delta\left(P_f + t - P_h\right)\frac{\partial X_h}{\partial \delta} + \delta\left(\frac{\partial P_f}{\partial X_f}\frac{\partial X_f}{\partial \delta} - P_h'\left(\frac{\partial(Y_h = X_h)}{\partial \delta}\right)\right)X_h \qquad (8.4)$$

$$\frac{\partial W}{\partial \delta} = \left(P_h - c - P_h'(1+\delta)X_h\right) + \left(\delta\left(P_f + t - P_h\right) - P_h'(1+\delta)X_h\right)\frac{\partial X_h}{\partial \delta}$$

$$+\left(P_f + t - P_h + \delta\frac{\partial P_f}{\partial X_f}\frac{\partial X_f}{\partial \delta}\right)X_h \qquad (8.5)$$

We have shown in the previous chapter that as long so $\delta < \tilde{\delta}$, the equilibrium occurs in domain DIII and as long as the dumping penalty rate varies in this range, i.e., $\delta \in \left(0, \tilde{\delta}\right)$, the equilibrium remains in this domain and the Nash equilibrium in this domain results in the following solutions for stage I variables for the foreign and home firms:

$$X_t^3 = \frac{6K + 3.5\left(1 + \frac{\delta}{2}\right)Y^c - 2\left(1 + \frac{\delta}{2}\right)L}{5 - 7S} \qquad (8.6)$$

and

$$Y_t^3 = \frac{4(1-S)L - 2Y_c - 2mK}{5 - 7S} \tag{8.7}$$

We use these stage I solution values to find the reduced form solutions for other variables, i.e., express all variables in terms of the parameters of the model. In this domain (DIII) the rule which the foreign firm uses to allocate sales in the foreign market is:

$$X_f = \frac{(2+3\delta)}{4(1+\delta)} X_t + \frac{Y_t}{4} - \frac{Y^c}{4} \tag{8.8}$$

By substituting X_t and Y_t, we get:

$$X_f = \left[\frac{(10+17\delta)K + \delta(1+\delta)7Y^c - \delta(1+\delta)4L}{4(1+\delta)(5-7S)} \right] \tag{8.9}$$

Similarly, the foreign and home firms' sales in the home market for this domain are given below.

$$X_h = \frac{(2+\delta)}{4(1+\delta)} X_t - \frac{Y_t}{4} + \frac{Y^c}{4} \tag{8.10}$$

$$X_h = \frac{\left[(2+\delta)7K - (1+\delta)8L + (1+\delta)14Y^c \right]}{4(1+\delta)(5-7S)} \tag{8.11}$$

and

$$Y_h = Y_t^3 = \frac{4(1-S)L - 2Y^c - 2mK}{5 - 7S} \qquad (8.12)$$

Given the Nash equilibrium in domain DIII, the price in the home country would be

$$P_h = A - \beta(Y_h + X_h) \qquad (8.13)$$

$$P_h = A - \beta\left(\frac{(2 + 2\delta - \delta^2)4L + (1 + \delta)(6Y^c + 3K)}{4(1 + \delta)(5 - 7S)}\right) \qquad (8.14)$$

Similarly price in the foreign country, in this case, is:

$$P_f = \alpha - \beta X_f \qquad (8.15)$$

$$P_f = \alpha - \beta\left(\frac{(10 + 17\delta)K + \delta(1 + \delta)7Y^c - \delta(1 + \delta)4L}{4(1 + \delta)(5 - 7S)}\right) \qquad (8.16)$$

Given the above solutions for dumping domain (DIII), it is clear that increase in the dumping penalty rate induces the home firm to expand its output whereas the foreign firm reduces its sales in the home market with the effect that the total sales in the home market falls causing the price to rise in this market. The following comparative statics prove this.

$$\frac{\partial P_h}{\partial \delta} = \beta\left[\frac{(2\delta + \delta^2)(24L - 21K - 42Y^c)}{(20 + 20\delta - 7\delta^2)^2}\right] \qquad (8.17)$$

and this can be rewritten as:

$$\frac{\partial P_h}{\partial \delta} = \beta \left[\frac{(2\delta + \delta^2)(\varpi - 1.75)12K}{(20 + 20\delta - 7\delta^2)^2} \right]$$

(8.18)

The above expression is positive as long as $\varpi > 1.75$. The increase in price, on the one hand, leads to an increase in the home firm's profits, and on the other hand, reduces the consumer surplus in this country. Thus, we can not say unambiguously which way the total welfare of the home country goes as the dumping penalty rate (δ) is raised in this domain, i.e., we can not analytically sign the expression $\partial W / \partial \delta$ of equation (8.5). Hence we resort to numeric simulation to examine the effects of increase in δ on the home country's welfare in this or even beyond this domain. Because when penalty for international price discrimination increases and δ goes beyond $\tilde{\delta}$, the foreign firm no longer finds it optimal to dump and, therefore, the Nash solution takes place on the boundary of DIII and DII domains. As explained earlier the dumping margin reduces to zero on the boundary and the home government can not extract any dumping revenues. What happens in this case is that the home firm likes the foreign firm to cut back its sales in the home market as a reaction to home firm's sales increase, in a similar fashion as it did while in domain DIII. But the foreign firm's reduction in its sales in the home market is less on boundary and in domain DII as compared to its response to the home firm's move in domain DIII which may result in increase in total sales in the home market and, thereby, may bring the price in home market down. When the solution to the stage I game is on

the boundary, there is no tariff revenue for the home country, therefore, the total welfare of the home country reduces to:

$$W|_B = \int_0^{Y_h+X_h} P_h(Y_h + X_h)d(Y_h + X_h) - cY_h - P_hX_h \tag{8.19}$$

The effect of change in δ on the home country's welfare, in this case is as follows:

$$\frac{\partial W|_B}{\partial \delta} = P_h\left(\frac{\partial(Y_h + X_h)}{\partial \delta}\right) + P_h'\left(\frac{\partial(Y_h + X_h)}{\partial \delta}\right) - c\frac{\partial Y_h}{\partial \delta}$$

$$-P_h\frac{\partial X_h}{\partial \delta} - X_hP_h'\frac{\partial(Y_h + X_h)}{\partial \delta} \tag{8.20}$$

$$\frac{\partial W|_B}{\partial \delta} = (P_h - c)\frac{\partial Y_h}{\partial \delta} - X_hP_h'\frac{\partial(Y_h + X_h)}{\partial \delta} \tag{8.21}$$

The boundary solution to stage I variables, as we have derived in the last chapter, is as follows:

$$X_t = \left(\frac{2+2\delta}{2+3\delta}\right)K \tag{8.22}$$

$$Y_t = Y^c + \frac{\delta}{1+\delta}X_t \quad \Rightarrow \quad Y_t^B = Y^c + \frac{2\delta}{2+3\delta}K \tag{8.23}$$

When the equilibrium occurs on the boundary, the foreign firm's sales in the home market
are determined by the following rule.

$$X_h = \frac{X_t^B - Y_t^B + Y^c}{2}$$

(8.24)

Therefore, the foreign firm's sale in the home country, in this case are:

$$X_h^B = \frac{2K}{2+3\delta}$$

(8.25)

The total sales in the home market are:

$$Y_t^B + X_h^B = Y^c + \frac{2\delta}{2+3\delta}K + \frac{2K}{2+3\delta} = Y^c + \left(\frac{1+2\delta}{2+3\delta}\right)K$$

(8.26)

From the above equations, when we substitute

$$P_h' = -\beta,$$

(8.27)

$$\frac{\partial\left(X_h^B + Y_h^B\right)}{\partial\delta} = \frac{K}{(2+3\delta)^2}, \text{ and}$$

(8.28)

$$\frac{\partial Y_h^B}{\partial\delta} = \frac{4K}{(2+3\delta)^2}$$

(8.29)

in equation (8.21), we get the following expression for the change in the home country's welfare on the boundary when there is a change in δ.

$$\frac{\partial W}{\partial \delta}\bigg|_B = (P_h - c)\frac{4K}{(2+3\delta)^2} + \beta X_h^B \frac{K}{(2+3\delta)^2} > 0 \tag{8.30}$$

We know, from the previous chapter, that when $\tilde{\delta} < \delta < \hat{\delta}$ the solution lays along the boundary of domains DIII and DII. The above equation implies that if dumping penalty rate is increased in this range, it enhances the home country's welfare unambiguously.

For the purpose of numeric simulation, we measure the change in home country's welfare slightly differently. Because our model is based on linear demand function, and if income distribution considerations are ignored, aggregate social welfare can also be measured as the sum of consumer surplus, home firm's profit, and tariff revenue. The welfare also depends on the domain in which equilibrium is attained. It is shown that imposition of dumping tariff raises the price in the home market which increases the home firm's profits but is detrimental to the consumers of the home country in domain DIII. There is another gainer in this case and that is the home country's government who collects dumping penalty from the foreign firm. The antidumping tariff is some proportion (δ) of the dumping margin $\big[(P_f(\delta)+t) - P_h(\delta)\big]$ and is assessed on each unit of the product the foreign firm sells in the home country (X_h).

To start with, we assume that Nash equilibrium takes place in the domain DIII and the dumping laws are either not enforced or the dumping penalty rate (δ) is zero. When the antidumping law is enacted, we trace the effect of this law on the home country's

welfare as δ increases. So the change in the home country's social welfare, ΔW, is measured as follows:

$$\Delta W = \Delta CS + \Delta FP + TR$$

where ΔW is the change in social welfare, ΔFP is the change in the home firm's profit, TR is tariff revenue and ΔCS is the change in consumer surplus. These changes are measured from laissez faire (δ=0) point and are calculated as follows:

$$\Delta CS = \left\{ P_h(\delta = 0) - P_h(\delta) \right\} \left[\frac{\left(Y_h(\delta) + X_h(\delta) + Y_h(\delta = 0) + X_h(\delta = 0) \right)}{2} \right] \qquad (8.31)$$

$$\Delta FP = \left[P_h(\delta) - C \right] Y_h(\delta) - \left[P_h(\delta = 0) - C \right] Y_h(\delta = 0) \qquad (8.32)$$

$$\Delta TR = \delta \left[\left(P_f(\delta) + t \right) - P_h(\delta) \right] X_h(\delta) \qquad (8.33)$$

The consumers surplus, home firm's profits, and tariff revenues depend on price in the home market (P_h), price in the foreign market (P_f), home firm's sales in home market (Y_h), foreign firm's sales in home market (X_h), and are ultimately function of the dumping tariff rate (δ) and the parameters of the model. The terms with δ=0 imply the values of these variables when there is no antidumping law in the home country or the when the dumping penalty rate is zero and are given below.

$$X_f(\delta = 0) = \frac{K}{2} \qquad (8.34)$$

124

$$X_h(\delta = 0) = \frac{14K + 14Y^c - 8L}{20} \qquad (8.35)$$

$$P_h(\delta = 0) = A - \beta\left(\frac{8L + 3K + 6Y^c}{20}\right) \qquad (8.36)$$

Now, by making appropriate substitutions, we can figure out the changes in consumer surplus (ΔCS), home firm's profits (ΔFP), and the tariff revenue in order to find out change in the home country's total social welfare in the presence of dumping penalty.

We get an expression for the change in social welfare of the home country by adding up the consumers surplus, producers surplus, and tariff revenue from the above equations. As can be seen, the social welfare is a function of parameters values of the model. We perform numerical simulation to examine the welfare effects of tariff rate changes, and see to what extent the results are sensitive to changes in the parameter values of the model.

We have already shown in the previous chapter that there is a sub-space of parameter values which ensures the Nash Equilibrium in domain DIII. This parameter space is defined by the following restrictions on the parameter values.

i. $4L - 2K - 7Y^c > 0 \quad or \quad \varpi > 1$ and $\qquad (8.37)$

ii. $\delta < \tilde{\delta} = \dfrac{2(4L - 2K - 7Y^c)}{14K + 21Y^c - 12L}$ $\qquad (8.38)$

In this type of simple duopoly model imposition of tariff in domain DIII may be welfare enhancing for the domestic country because along with the tariff revenues, a part of foreign firm's profit is also transferred to the home firm and together they may more than compensate for the loss of consumer surplus from the price increase in the home market. But when the dumping penalty rate is more than $\tilde{\delta}$, the solution is on the boundary and that results in an unambiguous increase in the home country's welfare.

We first perform numeric simulation by assigning a range of values to demand and costs parameters of the model which fulfill the above restrictions and see how the home country's social welfare is affected by changes in the antidumping tariff rate (δ). The following set of tables show the results of this exercise.

The following tables describe whether or not an optimal dumping penalty rate exist, the rate that maximizes the home country's total social welfare for different demand and costs conditions in the two countries. It can be seen from these tables that while in domain DIII, the home country's welfare varies with a change in dumping penalty rate (δ). But there is a local optimum δ which maximizes the welfare in this domain ($\delta = 0.3761$ in Table 3, $\delta = 0.2045$ in Table 4, and $\delta = 0.4$ in Table 5). But as soon as the penalty rate is increased beyond $\tilde{\delta}$ the home country's welfare jumps to a higher level and from there it increases monotonically with δ, which is as expected since we earlier show that even though there are no tariff revenues when the foreign firm does not price discriminate (on the boundary or in DII), the welfare is an increasing function of δ in these domains. We have also demonstrated earlier that on the boundary solution total sales in the home market go up as δ increases, i.e., $\partial(Y_h + X_h)/\partial\delta > 0$, thereby causing the price in this market to fall. This can be noticed here too that the price decreases with an increase in δ

Table 3: Simulation I

A	α	$\eta = \bar{\eta}$	δ	ΔCS	ΔFP	TR	ΔW
35	28	6	0.0000	0.0000	0	0	0
35	28	6	0.0470	-1.5620	1.7254	0.2955	0.4588
35	28	6	0.0940	-2.9439	3.2653	0.4958	0.8172
35	28	6	0.1410	-4.1728	4.6447	0.6215	1.0934
35	28	6	0.1880	-5.2703	5.8840	0.6878	1.3015
35	28	6	0.2350	-6.2541	7.0004	0.7059	1.4521
35	28	6	0.2821	-7.1389	8.0080	0.6845	1.5537
35	28	6	0.3291	-7.9366	8.9191	0.6301	1.6126
35	28	6	0.3761	-8.6573	9.7436	0.5476	1.6339
35	28	6	0.4231	-9.3094	10.4905	0.4408	1.6218
35	28	6	0.4701	-9.9002	11.1670	0.3126	1.5793
35	28	6	0.5171	-10.4356	11.7796	0.1651	1.5090
35	28	6	0.5641	-10.9209	12.3338	0	1.4128
35	28	6	0.7410	-8.2808	17.0498	0	8.7691
35	28	6	0.9179	-6.2014	20.5977	0	14.3963
35	28	6	1.0949	-4.5216	23.3606	0	18.8390
35	28	6	1.2718	-3.1365	25.5713	0	22.4348
35	28	6	1.4487	-1.9749	27.3795	0	25.4046
35	28	6	1.6256	-0.9868	28.8853	0	27.8986
35	28	6	1.8026	-0.1360	30.1584	0	30.0224
35	28	6	1.9795	0.6041	31.2487	0	31.8528
35	28	6	2.1564	1.2539	32.1926	0	33.4465
35	28	6	2.3333	1.8289	33.0178	0	34.8467
35	28	6	2.5103	1.8289	33.0178	0	34.8467
35	28	6	2.6872	1.8289	33.0178	0	34.8467
35	28	6	2.8641	1.8289	33.0178	0	34.8467
35	28	6	3.0410	1.8289	33.0178	0	34.8467

Table 4: Simulation II

A	α	$\eta = \overline{\eta}$	δ	ΔCS	ΔFP	TR	ΔW
60	45	10	0.0000	0.0000	0.0000	0.0000	0.0000
60	45	10	0.0227	-2.4270	2.6137	0.3144	0.5011
60	45	10	0.0455	-4.7071	5.0795	0.5498	0.9222
60	45	10	0.0682	-6.8518	7.4077	0.7149	1.2708
60	45	10	0.0909	-8.8714	9.6075	0.8174	1.5535
60	45	10	0.1136	-10.7752	11.6874	0.8636	1.7759
60	45	10	0.1364	-12.5714	13.6551	0.8593	1.9430
60	45	10	0.1591	-14.2675	15.5177	0.8091	2.0593
60	45	10	0.1818	-15.8705	17.2815	0.7174	2.1285
60	45	10	0.2045	-17.3863	18.9525	0.5877	2.1538
60	45	10	0.2273	-18.8207	20.5360	0.4231	2.1384
60	45	10	0.2500	-20.1787	22.0370	0.2265	2.0847
60	45	10	0.2727	-21.4650	23.4600	0	1.9950
60	45	10	0.3510	-14.8252	34.5829	0	19.7577
60	45	10	0.4293	-9.0707	43.8636	0	34.7930
60	45	10	0.5076	-4.0361	51.7178	0	47.6817
60	45	10	0.5859	0.4051	58.4461	0	58.8513
60	45	10	0.6641	4.3518	64.2712	0	68.6230
60	45	10	0.7424	7.8819	69.3612	0	77.2431
60	45	10	0.8207	11.0580	73.8453	0	84.9033
60	45	10	0.8990	13.9306	77.8244	0	91.7550
60	45	10	0.9773	16.5411	81.3784	0	97.9195
60	45	10	1.0556	18.9239	84.5711	0	103.4950
60	45	10	1.1338	18.9239	84.5711	0	103.4950
60	45	10	1.2121	18.9239	84.5711	0	103.4950
60	45	10	1.2904	18.9239	84.5711	0	103.4950
60	45	10	1.3687	18.9239	84.5711	0	103.4950

Table 5: Simulation III

A	α	$\eta = \overline{\eta}$	δ	ΔCS	ΔFP	TR	ΔW
35	28	10	0.0000	0.0000	0.0000	0.0000	0.0000
35	28	10	0.0333	-0.7158	1.0371	0.1127	0.4340
35	28	10	0.0667	-1.3705	1.9897	0.1936	0.8127
35	28	10	0.1000	-1.9707	2.8662	0.2476	1.1431
35	28	10	0.1333	-2.5223	3.6742	0.2789	1.4307
35	28	10	0.1667	-3.0303	4.4202	0.2907	1.6806
35	28	10	0.2000	-3.4990	5.1098	0.2857	1.8965
35	28	10	0.2333	-3.9320	5.7480	0.2660	2.0820
35	28	10	0.2667	-4.3326	6.3392	0.2335	2.2400
35	28	10	0.3000	-4.7038	6.8871	0.1896	2.3729
35	28	10	0.3333	-5.0479	7.3952	0.1354	2.4827
35	28	10	0.3667	-5.3671	7.8665	0.0719	2.5714
35	28	10	0.4000	-5.6634	8.3038	0	2.6403
35	28	10	0.5267	-4.0222	12.8223	0	8.8000
35	28	10	0.6533	-2.6785	16.4036	0	13.7251
35	28	10	0.7800	-1.5583	19.3107	0	17.7524
35	28	10	0.9067	-0.6103	21.7168	0	21.1065
35	28	10	1.0333	0.2024	23.7408	0	23.9432
35	28	10	1.1600	0.9067	25.4666	0	26.3733
35	28	10	1.2867	1.5229	26.9556	0	28.4785
35	28	10	1.4133	2.0666	28.2531	0	30.3197
35	28	10	1.5400	2.5499	29.3938	0	31.9437
35	28	10	1.6667	2.9822	30.4044	0	33.3867
35	28	10	1.7933	2.9822	30.4044	0	33.3867
35	28	10	1.9200	2.9822	30.4044	0	33.3867
35	28	10	2.0467	2.9822	30.4044	0	33.3867
35	28	10	2.1733	2.9822	30.4044	0	33.3867

so much so that it even falls below the laissez faire price level in the home country ($P_h(\delta = 0)$) and ΔCS becomes positive at this point. This can be seen when $\delta \geq 0.6041$ in Table 3, $\delta \geq 0.4051$ in Table 4, and $\delta \geq 0.2024$. A further increase in the dumping penalty rate beyond $\hat{\delta}$ (for parameter values in Table 3, $\hat{\delta} = 2.3333$, in Table 2, $\hat{\delta} = 1.0556$, and for Table 5, $\hat{\delta} = 1.667$) puts the solution in domain DII where it becomes independent of δ and the home country's welfare increases further. from here it can be concluded that it pays to a country in this situation to raise the dumping penalty rate (δ) so high that the foreign firm is forced not to price discriminate (solution in DII) and that would maximize the country's welfare.

This is contrary to the claims made by the US Commerce Department and also by other industrialized countries that dumping penalty they impose is equal to the dumping margin which we have been referring to as remedial tariff. In the context of our model this implies $\delta = 1$. How far the regulatory agencies are able to estimate the dumping margins correctly is a separate debate, but the exporters claim that these margins are in general overestimated in favor of domestic industry. In our model this would make the value of δ greater than 1. If we examine whether remedial and punitive tariff can be beneficial for the home country under different demand and cost conditions, we find in these tables that any punitive penalty rate ($\delta > 1$) can be welfare enhancing for the home country. In all cases change in home county's welfare is positive whenever such a tariff is imposed.

If we assume that a country is constrained by some obligation that does not allow it to increase the dumping penalty rate δ beyond $\tilde{\delta}$ then another factor which seems to affect the optimal penalty rate choice in our model is the fixed or the capacity cost, η and $\bar{\eta}$. When we increase capacity costs for both the home and the foreign firms while holding all other parameter values constant, the optimal dumping penalty rate increases. In

Table 3 and 5 we change values $\eta = \overline{\eta}$ from 6 to 10, we find that optimal δ increase from 0.3761 to 0.400. We can replicate this trend for other sets of parameters too.

Now we analyze the situation when the home and foreign firms' best response curves intersect in domain DI, and dumping does not take place in laissez faire equilibrium. The restriction on the parameter values, that we laid down in the previous chapter, which ensure crossing of the two firms' best response curves in domain DI is $\varpi < 1$. Further restrictions that may cause intersection of the best response functions of the two firms in domain DII or on the boundary of DII and DIII along with in DI are as follows:

Given $\varpi + \sigma < 2,$ (8.39)

if $\quad \delta > \breve{\delta} = \dfrac{2}{3}\left(\dfrac{\varpi + \sigma - 1}{2 - \varpi - \sigma}\right),$ best response curves cross in DII, (8.40)

if $\quad < \delta < \breve{\delta}$ best response curves cross at the boundary. (8.41)

We assign numeric values to all the parameters of our model which fulfill the above conditions and see if there are multiple local solutions. We also try to find if a global solution exists. By using one set of values, $A = 100, \delta = 60, \beta = 2, C = \overline{C} = 4,$ $\eta = \overline{\eta} = 6,$ and $t = 1,$ generate Table 6. With these parameter values, $\breve{\delta} = 0.2342$ which implies that if $0 < \breve{\delta} < 0.2342,$ the solution is in domain DI and possibly on the boundary, and if $\breve{\delta} > 0.2342,$ the solution is in DI and may also be in DII. The pairs of solution values in different regions, $X_t, Y_t,$ are given in columns 2 and 3 of the table which show that as δ increases the foreign and home firms' best response curves intersect each other at the boundary or in DII as well as in DI. π_h is the home firm's profit associated with

Table 6: Simulation IV

δ	X_t	Y_t	$Y_I^B(X_t^B)$	π_h	$\pi_h(Y_I^B)$	ΔCS	ΔPS	ΔW	ΔCS(Y_I^B)	ΔPS(Y_I^B)	ΔW(Y_I^B)
0.0000	25.65	18.20		668.86		0.00	0.00	0.00			
0.0300	24.64	20.22	18.54	710.58	712.99	73.58	33.65	107.23	-74.15	42.78	-31.36
0.0600	24.31	20.88	18.65	727.18	731.59	88.51	47.61	136.12	-107.30	60.95	-46.35
0.0900	24.01	21.48	18.75	742.07	748.87	102.35	60.08	162.43	-137.68	77.82	-59.86
0.1200	23.73	22.04	18.84	755.51	764.96	115.22	71.28	186.49	-165.61	93.54	-72.08
0.1500	23.47	22.56	18.93	767.67	779.97	127.21	81.37	208.58	-191.38	108.20	-83.18
0.1800	23.23	23.04	19.01	778.73	794.02	138.41	90.50	228.91	-215.24	121.93	-93.31
0.2100	23.00	23.49	19.08	788.83	807.18	148.90	98.80	247.70	-237.37	134.79	-102.58
0.2342	22.83	23.83		796.36		156.90	104.97	261.86			
0.3192	22.83	23.83		796.36		156.90	104.97	261.86			
0.4042	22.83	23.83		796.36		156.90	104.97	261.86			
0.4892	22.83	23.83		796.36		156.90	104.97	261.86			
0.5742	22.83	23.83		796.36		156.90	104.97	261.86			
0.6592	22.83	23.83		796.36		156.90	104.97	261.86			
0.7442	22.83	23.83		796.36		156.90	104.97	261.86			

$A = 100, \alpha = 60, \beta = 2, C = \overline{C} = 4, \eta = \overline{\eta} = 6, t = 1$

$\widetilde{X} = 27.1164$

corresponding solution values. At the boundary the solution value for the foreign and home firm is X_t^B, Y_t^B, respectively. But given the solution output of the foreign firm at the boundary, X_t^B, the home firm can also choose another (lower) output by using the solution rule R_1, i.e., $Y_I^B : R_1(X_t^B) = 0$, and this is calculated in column 4 of Table 6. When we compare the home firm's profit associated with this response $\pi_h(Y_I^B(X_t^B))$, given in column 6, with its profits resulting from its output on the boundary, Y_t^B, we find that $\pi_h(Y_I^B(X_t^B)) > \pi_h(Y_t^B)$. Therefore, the home firm would like to have output Y_I^B instead of its solution output Y_t^B as its response to the foreign firm's output X_t^B. However, this cannot be an equilibrium because X_t^B is not the foreign firm's best response to the home firm's Y_I^B, its best output is a lot more than X_t^B in this case. Therefore, no-dumping solution in domain DI will prevail ultimately and will be the global solution in this case. This may be due to the fact that with these parameter values the jump in the home firm's best response function from R_1 to R_2 occurs at $\tilde{X} = 27.1164$ which is even greater than the solution value of X_t in DI (X_t^1).

We simulate the same no-dumping solution, this time with a different set of parameter values, $A = 195, \delta = 110, \beta = 2, C = \overline{C} = 4, \eta = \overline{\eta} = 7$, and $t = 1$, and the results are shown in Table 7 where all the variables are the same as defined in Table 6 with an additional column where value of X_4 is caculated. For these parameter values $\breve{\delta} = 0.1382$ and the jump in the home firm's best response function from R_1 to R_2 occurs at $\tilde{X} = 48.56$ which is greater than the solution value of X_t in DII and less than the solution value X_t in DII. Now in laissez faire case (when there is no dumping law) dumping does not take place in equilibrium. However, if antidumping law is introduced in the home country and penalty for dumping (δ) is gradually raised, equilibrium may shift to the regions where decisions of firms are affected by the antidumping law. As can be noticed

Table 7: Simulation VI

δ	X_t	Y_t	$Y_I^B(X_t^B)$	π_h	$\pi_h(Y_I^B)$	ΔCS	ΔPS	ΔW	$\Delta CS(Y_I^B)$	$\Delta PS(Y_I^B)$	$\Delta W(Y_I^B)$	X_4
0.0000	52.00	37.00		2450		0	0	0				58.00
0.0300	48.79	43.42	38.07	2629	2711	517	153	671	-439	257	-182	54.81
0.0600	48.14	44.72	38.29	2679	2784	579	198	777	-571	330	-241	52.10
0.0770	47.79	45.42	38.40	2705	2824	611	221	833	-641	369	-272	50.74
0.1070	47.22	46.56	38.59	2746	2890	666	259	924	-757	434	-323	48.60
0.1370	46.69	47.63	38.77	2784	2951	716	292	1008	-863	494	-369	46.74
0.1670	46.19	48.61	38.94	2818	3008	763	322	1085	-962	551	-411	45.09
0.1970	45.74	49.53	39.09	2849	3062	807	349	1156	-1053	604	-449	43.64
0.1382	46.67	47.67	38.78	2785	2953	718	293	1011	-867	497	-371	46.67
0.2232	46.67	47.67	39.21	2785	2952	718	293	1011	-793	494	-299	42.49
0.3082	46.67	47.67	39.57	2785	2951	718	293	1011	-732	491	-241	39.42
0.3932	46.67	47.67	39.87	2785	2950	718	293	1011	-680	489	-192	37.07
0.4782	46.67	47.67	40.13	2785	2948	718	293	1011	-636	486	-150	35.22
0.5632	46.67	47.67	40.35	2785	2947	718	293	1011	-598	484	-114	33.71
0.6482	46.67	47.67	40.54	2785	2945	718	293	1011	-565	481	-83	32.46

$A = 195, \alpha = 110, \beta = 2, C = \overline{C} = 4, \eta = \overline{\eta} = 7, t = 1$

$\widetilde{X} = 48.56$

that if $\delta < 0.1382$, we have intersection of the foreign and home firms' best response curves in DI and on the boundary. However the domain DI solution dominates for the same reasons explained in the previous paragraph. But when $\delta = 0.1070$, the jump in the home firm's best response curve takes place from R_1 to the intersection point of R_2 and the boundary which has been defined as X_4 $(X_4 = 48.6$ when $\delta = 0.1070)$. This causes existence of multiple solutions in no-dumping domain DI $\left(X_t^1 = 52 \right)$, at the jump $\left(\tilde{X} = 48.56 \right)$, and at the boundary of DII and DIII $\left(X_t^B = 46.22 \right)$. Further increase in δ, beyond 0.1070, soon makes $X_4 < X_t^2 = 46.67$, and that results in multiple solutions in domains DI, DII, and at $\tilde{X}$ $(X_t^1 = 52$, $\tilde{X} = 48.56$, and $X_t^2 = 46.67)$. Which of these solutions would prevail, we can not say anything for sure. Some sort of trade policy like VER or some other type of government intervention may be able to force one of these solution over the others. To analyze this we need to put more structure in our model.

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APPENDIX A

We will examine here whether there exist such X_t which makes home firm's profit in domain D I exactly equal toits profits in domain D II.

X_1, X_2 are defined in chapter 6 as follows:

$$X_1 / X_t : R_1(X_1, Y^c) = 0 \tag{A.1}$$

$$X_1 = 2L - \frac{7}{2} Y^c \tag{A.2}$$

$$X_2 / X_t : R_2(X_1, Y^c) = 0 \tag{A.3}$$

$$X_1 = 2L - 3 Y^c \tag{A.4}$$

$$X_2 > X_1 \tag{A.5}$$

Now I define $\widetilde{X} \in (X_1, X_2)$ s.t. $\tag{A.6}$

$$\widetilde{X} / X_t : \widetilde{\pi}_h(\widetilde{X}, Y_1) = \widetilde{\pi}_h(\widetilde{X}, Y_2) \tag{A.7}$$

where

$$Y_1 / Y_t : R_1(\widetilde{X}, Y_1) = 0 \tag{A.8}$$

$$Y_2 / Y_t : R_2(\widetilde{X}, Y_1) = 0 \tag{A.9}$$

The home firm's profits in the domain D I are:

$$\widetilde{\pi}_I = (A - \beta Y_1 - \beta X_h) Y_1 - (C + \eta) Y_1 \tag{A.10}$$

$$\widetilde{\pi}_I = (A - (C + \eta) - \beta Y_1 - \beta X_h) Y_1 \tag{A.11}$$

Where

$$Y_1 = \frac{2}{3}\left[L - \frac{Y^c}{4} - \frac{\tilde{X}}{2}\right]; X_h = \frac{\tilde{X}}{2} + \frac{Y^c - Y_t}{4}, \text{ and } L = \frac{A - (C + \eta)}{\beta}.$$ (A.12)

Therefore, when substitutions are made for X_h and L, $\tilde{\pi}_I$ becomes:

$$\tilde{\pi}_I = \left(L - Y_1 - \frac{\tilde{X}}{2} - \frac{Y^c + Y_1}{4}\right)\beta Y_1$$ (A.13)

$$\tilde{\pi}_I = \left(L - \frac{\tilde{X}}{2} - \frac{Y^c}{4}\right)\beta Y_1 - \frac{3}{4}\beta Y_1^2$$ (A.14)

After substituting for Y_1, the above expression reduces to the following.

$$\tilde{\pi}_I = \left(L - \frac{\tilde{X}}{2} - \frac{Y^c}{4}\right)^2 \frac{\beta}{3}$$ (A.15)

Similarly, the home firm's profits in domain D II are:

$$\tilde{\pi}_{II} = (A - \beta Y_2 - \beta X_h)Y_2 - (C + \eta)Y_2 ,$$ (A.16)

and values of Y_2 and X_h in this domain are :

$$Y_2 = \left[L - \frac{Y^c}{2} - \frac{\tilde{X}}{2}\right]; X_h = \frac{\tilde{X}}{2} + \frac{Y^c - Y_t}{2}.$$ (A.17)

After substituting for Y_2 and X_h and simplification, DII profits are:

$$\tilde{\pi}_{II} = \left(L - \frac{\tilde{X}}{2} - \frac{Y^c}{2}\right)^2 \frac{\beta}{2}$$ (A.18)

To find out if D I and D II profits are identical at certain $X_t = \tilde{X}$, we compare $\tilde{\pi}_I \text{ and } \tilde{\pi}_{II}$.

$$\tilde{\pi}_{II} - \tilde{\pi}_I = \frac{\beta}{6}\left\{3\left(L - \frac{Y^c - \tilde{X}}{2}\right)^2 - 2\left(L - \frac{Y^c}{4} - \frac{\tilde{X}}{2}\right)^2\right\} \tag{A.19}$$

Let $\Psi = L - \dfrac{\tilde{X}}{2}$, then $\qquad$ (A.20)

$$\tilde{\pi}_{II} - \tilde{\pi}_I = \frac{\beta}{6}\left\{3\left(\Psi - \frac{Y^c}{2}\right)^2 - 2\left(\Psi - \frac{Y^c}{4}\right)^2\right\} \tag{A.21}$$

$$\tilde{\pi}_{II} - \tilde{\pi}_I = \frac{\beta}{6}\left\{3\Psi^2 + 3\left(\frac{Y^c}{2}\right)^2 - 3\Psi Y^c - 2\Psi^2 - 2\left(\frac{Y^c}{4}\right)^2 + \Psi Y^c\right\} \tag{A.22}$$

$$\tilde{\pi}_{II} - \tilde{\pi}_I = \frac{\beta}{6}\left\{\frac{5}{8}(Y^c)^2 - 2\Psi Y^c + \Psi^2\right\} \tag{A.23}$$

If profits in domain D I and D II are same at some point, then

$$\frac{5}{8}(Y^c)^2 - 2\Psi Y^c + \Psi^2 = 0 \tag{A.24}$$

Applying the quadratic formula yields the following roots for the above equation.

$$\Psi = \frac{2Y^c \pm \sqrt{4Y^{c2} - 4\frac{5}{8}Y^{c2}}}{2} \tag{A.25}$$

$$\Psi = Y^c \pm Y^c\sqrt{\frac{3}{8}} \tag{A.26}$$

$\Psi_1 = 1.6124 Y^c \qquad$ Root 1 $\qquad$ (A.27)

$\Psi_1 = 0.3876 Y^c \qquad$ Root 2 $\qquad$ (A.28)

We use root 2 because root $2 \notin (X_1, X_2)$

$$\Psi_1 = L - \frac{X_I}{2} = 1.6124 Y^c \tag{A.29}$$

Therefore, if

$$X_t > 2(L - 1.6124Y^c)$$ R1 is the relevant solution rule and if (A.30)

$$X_t < 2(L - 1.6124Y^c)$$ R2 is the relevant solution rule. (A.31)

Thus, a discontinuity in the home firm's reaction function occurs at

$$X_t = \widetilde{X} = 2(L - 1.1624Y^c)$$ (A.32)

APPENDIX B

Here we look for values of X_t which make the home firm's profits alike in domain D I and on the boundry. For this purpose we define a function $G(X)$ such that

$$G(X) = \pi_h^B - \pi_h^I = 0 \qquad (B.1)$$

where π_h^B is the home firm's profit on the boundry of domaim D II and D III and π_h^I is it profits in domain D I and if we can show the existence of roots of the function $G(X)=0$, those are the vallues of X_t which tie the home firm's profits in D I and on B. From Appendix A we have profits in D I

$$\pi_h^I = \left(L - \frac{\tilde{X}}{2} - \frac{Y^c}{4}\right)^2 \frac{\beta}{3} \qquad (B.2)$$

and profits on the boundry are;

$$\pi_h^B = (A - \beta Y_t - \beta X_h)Y_t - (C + \eta)Y_t \qquad (B.3)$$

$$Y_t = Y^c + \frac{\delta}{1+\delta} X_t \qquad (B.4)$$

$$X_h = \frac{(2+\delta)}{4(1+\delta)} X_t + \frac{Y^c}{4} - \frac{Y_t}{4} \qquad (B.5)$$

When the values of Y_t and X_h on the boundry are substituted, we get the following profit function on the bioundry.

$$\pi_h^B = \beta\left\{L - Y^c - \frac{(1+2\delta)}{2(1+\delta)}X_t\right\}\left(Y^c + \frac{\delta}{1+\delta}X_t\right) \tag{B.6}$$

At this point we further define grouping of some parameters that will facilitate the algebric menapulations. In chapter IV we defined

$$J = 4L - 2K - 7Y^c \ . \ \text{Now, let} \tag{B.7}$$

$$W = 4L - 2K - 6Y^c \tag{B.8}$$

and

$$\frac{W}{4} - \frac{K}{2} = a = L - \frac{3}{2}Y^c \ , \ \text{Therefore} \tag{B.9}$$

$$L - Y^c = a + \frac{Y^c}{2} \ \text{and} \ L - \frac{Y^c}{4} = a + \frac{5}{4}Y^c \tag{B.10}$$

When these are substituted in the above profit functions, we get

$$G(X) = \beta\left[\left\{\left(a + \frac{Y^c}{2}\right) - \frac{(1+2\delta)}{2(1+\delta)}X_t\right\}\left(Y^c + \frac{\delta}{1+\delta}X_t\right) - \frac{1}{3}\left\{\left(a + \frac{5}{4}Y^c\right) - \frac{X_t}{2}\right\}^2\right] \tag{B.11}$$

$$G(X) = -\frac{1}{3}\left(-3aY^c - \frac{3}{2}Y^{c2} + a^2 + \frac{25}{16}Y^{c2} + \frac{5}{2}aY^c\right)$$
$$+ X_t\left\{\frac{-6(1+2\delta)Y^c + 12\delta a + 6\delta Y^c + 4(1+\delta)a + 5(1+\delta)Y^c}{12(1+\delta)}\right\} \tag{B.12}$$
$$- X_t^2\left\{\frac{\delta(1+2\delta)}{2(1+\delta)^2} + \frac{1}{12}\right\}$$

$$G(X) = -\frac{1}{3}\left(a - \frac{Y^c}{4}\right)^2 + X_t\left\{\frac{(1+4\delta)}{3(1+\delta)}a - \frac{Y^c}{12}\right\} - X_t^2\left\{\frac{\delta(1+2\delta)}{2(1+\delta)^2} + \frac{1}{12}\right\} = 0 \tag{B.13}$$

The roots are found by the quadratic formula.

$$X^j = \frac{\left\{\frac{(1+4\delta)}{3(1+\delta)}a - \frac{Y^c}{12}\right\} \pm \sqrt{-\left\{\frac{(1+4\delta)}{3(1+\delta)}a - \frac{Y^c}{12}\right\}^2 - 4\left[\frac{1}{3}\left(a - \frac{Y^c}{4}\right)^2\left\{\frac{\delta(1+2\delta)}{2(1+\delta)^2} + \frac{1}{12}\right\}\right]}}{-2\left\{\frac{\delta(1+2\delta)}{2(1+\delta)^2} + \frac{1}{12}\right\}}$$

(B.14)

Since we have shown the existence of the roots, therefore, it implies that at $X_t = X^j$ the home firm's profits same in domain D I and on the boundry (B), thus the is a possible jump from D I to B in the home fir's best response curve.