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Essays on international trade and Bayesian forecasting

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ESSAYS ON INTERNATIONAL TRADE AND BAYESIAN FORECASTING

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ABSTRACT

Economic theory is subject to continual analysis. While theories themselves are sometimes widely accepted, nuances of theory are persistently scrutinized. Researchers have not isolated this debate from a simply theoretic standpoint. Empirical methods in microeconomics also provide a forum for disagreement. This dissertation studies two topics of microeconomic theory that are constantly in debate: integration and cost function estimation. From the standpoint of theoretical integration models in international trade theory, the concept of foreign direct investment is studied in both a horizontal and vertical setting. With respect to horizontal integration, this dissertation modifies the Brander-Krugman reciprocal dumping model to evaluate the effects on production and profit in an international duopoly under settings of non-controlling interest and managerial control. Counterintuitive results abound with managerial control, in that the acquiring firm will increase its exports abroad, despite the presence of transportation costs. Additionally, a discussion of antitrust and nationalist considerations that drive integration decisions is presented. This presents an introduction to a branch of theoretical literature that has seen constant conjecture: vertical integration. Various models of vertical integration are discussed, with the Ordover, Saloner, and Salop model in the foreground. The vertical integration model in this dissertation uses internal transfer pricing to describe the effects of input sales between the downstream and upstream divisions of a merged firm. With price leadership in the input market, foreclosure of downstream firms will occur, and these firms move toward a collusive equilibrium in the absence of tacit collusion among the downstream competitors. The dissertation concludes with a discussion of a debate among empirical researchers concerning the estimation of cost functions. There has been considerable discussion regarding the imposition of regularity conditions on cost functions. These conditions are imposed on the translog, and it seen that forecasting results are improved as a result. This leads to an important conclusion: economic theory matters in empirical work. While the constant scrutiny of theory will never conclude, this dissertation attempts to improve upon existing integration theory, and uses widely accepted economic theory to improve the means in which cost functions are estimated in empirical research.

CHAPTER ONE

INTRODUCTION TO THE DISSERTATION

This dissertation comprises essays on both theoretical and empirical issues in applied microeconomics. The first three essays of the dissertation focus on current integration issues in international trade, adding to recent literature. Integration, or the merging of two firms, remains a widely researched topic in the economics literature. The interest is motivated, in part, by the tremendous growth in mergers and acquisitions in the United States in the latter half of the 1990s. The fourth essay deals with empirical issues in analyzing cost, in particular, analyzing the forecasting accuracy of a flexible functional form under the imposition of constraints. This study uses data from the electricity generating industry, an industry with significant policy interest. Electricity deregulation is currently a much-debated topic in several states. The winter of 2000-01 was riddled with "rolling blackouts" in the state of California, fueling additional discussion of the question of deregulation and consequently, re-regulation.

This introduction offers a brief overview of the essays that follow in this dissertation. A comprehensive review of the integration literature in international trade immediately follows this introduction to the dissertation. This literature review presents the setting for the next three chapters dealing with horizontal and vertical mergers. The relevant literature for the cost analysis is more recent (and hence limited in scope). Therefore, the literature review for that topic is included in the empirical essay itself.

Integration typically takes one of two forms, horizontal and vertical. The first two essays in this dissertation deal with horizontal integration, a merging between two firms in the same level of the production process. The third essay deals with vertical integration, a merging between two firms at different levels of the production process.

The Brander-Krugman reciprocal dumping model is extended to analyze horizontal integration in the context of international trade. This widely accepted model is convenient given its simplicity (in adhering to Occam's razor). The basic framework envisions a world duopoly, with one firm in each of the two countries. Horizontal integration entails the firm in the domestic country acquiring partial or complete ownership of the firm in the foreign country. In the context of non-controlling interest

and output decisions, assuming only two firms does not lose the generality of the overall results.

The third chapter presents the model and its initial extension, assuming that the degree of ownership that the domestic firm acquires is exogenous. The two firms begin as a symmetric duopoly (which is a key assumption of the Brander-Krugman model), in which the ownership interest of the domestic firm in the foreign firm is zero. The question is, how does the acquisition of a competitor affect the production, profit, and trade patterns of the initial duopoly? There will be some level of interest in which the domestic firm acquires managerial control of the foreign firm, clearly allowing the domestic firm to exercise decision-making over the foreign firm. Any interest below that level however, leaves the acquiring firm with a non-controlling interest (hence a share of the profits), but no managerial control. While this essay describes the effects of ownership, it is not concerned with the optimal level of ownership of the foreign firm. The fourth chapter addresses this question.

In the absence of further analysis, it stands to reason that with no exogenous impediments to ownership, the domestic firm would continue to acquire the foreign firm until full ownership is achieved. This is because the degree of ownership variable not only reflects ownership, but the fraction of foreign firm profit accruing to the domestic firm. With managerial control, the industry goes from a symmetric duopoly to that of a multiplant monopoly.

Given this fact, an interesting question remains. Why do we see firms acquiring a non-controlling interest when the model predicts that it is better to obtain total ownership? Very simply, the answer lies in the presence of exogenous constraints. In the United States for example, the federal government will likely prevent any horizontal merger that yields over seventy-five percent market share to the merged firm. Horizontal restraints that would significantly hinder competition are deemed “illegal per se” by the federal government. The formations of monopolies or similar conspiracies to monopolize are illegal as described under antitrust laws such as the Sherman and Clayton acts.

There may also, however, be other restraints on the acquisition of a controlling interest. For example, China has pursued a highly nationalist economic development strategy. Foreign firms are sometimes prohibited from acquiring managerial control of

enterprises in China, despite its "open door" policy. The fourth chapter presents a Kuhn-Tucker optimal ownership model to deal with situations of antitrust and external ownership constraints.

The essay in the fifth chapter shifts attention from horizontal integration to vertical integration in international trade. Specifically, the essay pursues backward vertical integration, the form of vertical integration in which a firm merges with an input supplier. The model assumes that there are two upstream (supplier) firms, both located in the home market. Additionally, there are three downstream (final product) firms. One is located in the home market, and the other two are located in two foreign countries. These downstream firms are all rivals in the home market.

This essay assumes trade protection as a precondition. One of the foreign firms increases its volume of exports to the home country, which induces the home government to impose tariffs on all imports, including those of the other foreign competitor. After the tariff is imposed, the firm that flooded the home market with exports vertically integrates with one of the two upstream firms in that market, establishing a presence. The literature details this process "protection-building trade" (PBT).

If this newly integrated firm assumes a price leadership role in the input market, then this could forestall potential counterintegration by one of the downstream rivals. Thus, the integrated firm enjoys profits from both a downstream division and an upstream division. One interesting result found in this essay is that the prevention of counterintegration causes all downstream firms to move toward a collusive equilibrium, in the absence of even tacit collusion in the downstream market. When the vertically integrated firm assumes the role of input price leader, it forecloses itself as well as its downstream rivals. As long as counterintegration is prevented, the downstream rivals move toward the collusive equilibrium as they reduce production in the presence of higher input prices.

The aforementioned essays all deal with interrelated cases concerning integration in the context of international trade. The sixth chapter presents an essay that is distinct from the previous ones in terms of area of study. The final essay of this dissertation uses the Bayesian cost frontier and the translog flexible functional form to evaluate cost forecasting accuracy with and without the imposition of regularity conditions. In

empirical studies of estimating cost functions, sometimes economists try to find a model that fits data too perfectly, thereby "overfitting" a regression to the data. In such applications, overfitting sometimes violates the relationships and parametric restrictions that are implied by cost theory.

This problem has led some economists to suggest imposing regularity conditions locally or "regionally," retreating from restricting globally or not at all. Regularity conditions of cost functions are monotonicity, concavity, and homogeneity of degree one. With respect to monotonicity, this implies that cost must rise if input prices increase. Similarly, cost must rise if output increases. Concavity of a cost function implies downward-sloping (i.e., well-behaved) input demand functions. Homogeneity of degree one implies that as input prices increase by some factor t, total cost must rise by the same factor. In the literature, it turns out that concavity is violated much more often than monotonicity. These violations of economic theory will yield inaccurate and biased parameter estimates.

The final essay uses the Bayesian cost frontier and the translog form to estimate a cost function that is both constrained (with regulations imposed regionally) and unconstrained. The estimation uses data from electricity generating plants using natural gas as the primary fuel. In order to determine whether forecasting is improved when imposing regularity conditions, the mean square error, the mean absolute error, and the mean standard deviation are all calculated. If forecasting is improved with the imposition of regularity conditions, this implies that economic theory matters in empirical analysis. Interestingly, each measure of forecasting accuracy shows that the functional form with the constraints imposed performs better than the unconstrained model. This is an important finding that may influence the way economists perform economic analyses in the future.

CHAPTER TWO

LITERATURE REVIEW

<u>Dissertation Focus</u>: The following dissertation is an analysis of issues in theoretical and applied microeconomics. The first three essays concern a study of horizontal and vertical mergers in international trade. Specifically, the first two of these essays deal with horizontal integration among international competitors. An analysis of changes in firm output, exports, and profit is pursued in these chapters. The third essay is an analysis of vertical integration. Given a world with three downstream firms and two upstream firms, this essay illustrates the effects of vertical integration between two firms in a situation where all downstream firms compete for the home market. A study of the effects on downstream firm profitability is pursued in the presence of vertical integration between a home upstream firm and a foreign downstream firm when there is price leadership in the input market.

It is necessary to describe a comprehensive review of the literature prior to the presentation of these essays. In each of the integration chapters, a certain extension is mentioned prior to the description of the model that is to be used. In order to better understand the extensions, a thorough review of the literature is therefore necessary. An understanding of prior research assists in finding the proper placement of this work in the literature.

The final essay of the dissertation is an analysis of the forecasting accuracy of a flexible functional form (the translog) with and without the imposition of regularity conditions in estimating a cost function. There has been a back-and-forth debate among economists as to the validity of imposing such conditions on various functional forms. Regularity conditions in cost theory are monotonicity, concavity, and homogeneity of degree one in input prices. Much empirical research produces results which violate basic economic theory. As a result, estimates of elasticities tend to be biased. The issue of whether or not conditions should be imposed concerns the loss of flexibility of these forms upon the imposition of those conditions. Flexibility is how well a regression fits the data upon which it is based. Some economists argue that regressions tend to "overfit" the data, and as a result, theory is violated. Hence this is the rationale for imposing regularity conditions. Given the ongoing debate and recent contributions concerning cost

estimation, a review of the background literature is presented at the beginning of the final essay.

Given the length of this review, this chapter is organized into several sections and subsections for the sake of clarity.

2.1. Horizontal Integration:

2.1.A. Horizontal Integration and Reciprocal Dumping:

The beginning of this literature review addresses the theory of reciprocal dumping. This theory is presented due to the fact that the first two essays utilize an extension of the reciprocal dumping model. This widely-accepted model in international trade theory is a useful benchmark given its simplicity. An underlying assumption of this model is the existence of an international duopoly. Given that the first two essays concern international horizontal mergers, the use of this model seems ideal.

Firms wishing to increase their presence in other markets abroad have two primary avenues with which to do so. The first of these, exporting, is undoubtedly the most common method firms utilize for tapping into foreign markets. (The second is foreign direct investment, discussed below.) In past years, it was common for the United States to export automobiles and other capital-intensive goods to other countries. At the same time the United States, as well as other countries, would import similar goods from abroad. This notion of intraindustry trade was originally thought to be due to slight product differentiation. This concept is typical in market environments such as oligopoly and most certainly monopolistic competition. James A. Brander (1981) noted that initially when we see trade in slightly differentiated products, it is due to consumers' desire for variety. Presumably, with two-way trade in a commodity such as ham, Americans may prefer Danish ham, while the United States exports ham to Denmark for the same reason.

Brander goes further in that trade between two nations may be in identical goods. This type of trade is described as *cross-hauling*. Brander pursues this model in a Cournot setting, assuming that countries involved in trade (A--home and B--foreign) are identical. There exists one firm in each country, with the firms being symmetric, producing output at an identical marginal cost. The assumption of constant marginal cost is a key supposition in that it allows Brander to separate domestic and foreign markets. Firms can

then maximize profit with respect to both the domestic and the export markets. Increasing returns and transport costs are assumed. Transport costs are of the "iceberg" form; when output x is exported to another country, the quantity gx arrives in that country, where $0 \leq g \leq 1$. Lastly, firms play Cournot, in that each firm assumes that the other's output in each market remains the same. Firms remain in the industry only in the absence of economic losses.

Given the assumed symmetry, as transportation costs fall (i.e., as iceberg g approaches one), the solution approaches a standard Cournot equilibrium. Intuitively, a greater volume of foreign goods will enter the domestic market when the costs of transportation fall. With symmetry, this market share is split evenly between the two firms. Brander also claims that as world income rises, cross-hauling would also rise, a standard result with well-behaved demand functions. As income rises, total consumption rises, and some of this consumption is in the form of imported goods. The key result is that there exists a level of the iceberg transport cost parameter g in which markets will be invaded by the other firm. This is the cross-hauling that Brander wishes to explain.

Brander's framework is incomplete, however, in that while he models the conditions in which two-way trade develops, he does not provide reasons for exactly why such trade arises. He simply notes mathematically how trade arises. In fact, a referee points out that trade develops from dumping.

This insight leads Brander along with co-author Paul Krugman (1983) to expand and improve upon his previous work. Using the same model and assumptions as before (with the exception that one nation is now "domestic" while the other is "foreign"), Brander and Krugman show that this dumping situation that develops in the market for identical goods is in fact reciprocal. In other words, when the two firms compete Cournot, each firm is dumping its output in the other firm's market. Brander and Krugman call this phenomenon *reciprocal dumping*.

Dumping in its most innocent form is the activity of a firm selling its output in a foreign market at a price that is less than the foreign firms are charging. For example, if Mexico were selling steel to the United States at a price that is less than U.S. firms charge, American steel firms would likely claim that Mexico was dumping steel into the U.S. market. Dumping is actually a form of third-degree price discrimination. From a

firm's standpoint, it sells output both in its home market and to a foreign market. It is assumed that the foreign demand for home output is highly elastic at the home firm's foreign market price. Using the steel example above, U.S. steel consumers are highly price responsive to Mexican steel. A slight increase in the price of Mexican steel in the U.S. could cause a rather large shift away from Mexican steel purchases and toward American steel. The entire basis for third-degree price discrimination is that two separate groups have different elasticities of demand. The more elastic group will be faced with the lower price, due to that group's high responsiveness. Given this, Mexican steel will be priced below American steel in U.S. markets.

Another form of dumping is the far more anticompetitive predatory dumping. In this instance, foreign goods are sold in domestic markets at not only a lower price, but below the marginal cost of production of the foreign firm. The motive for predatory dumping is clearly to drive out competition. The firm engaging in dumping is willing to incur an economic loss in the short run in exchange for driving out foreign competitors, after which it assumes a monopoly position in the targeted market. While dumping as described above will most certainly draw the ire of domestic firms, predatory dumping will undoubtedly be deemed as anticompetitive. Guilty parties in the U.S., for example, would be faced with antidumping duties as a result of their actions.

Brander and Krugman show that in the presence of positive transportation costs, each firm has a larger market share in its own market than in the other market. This is not surprising since the two firms are symmetric. Transportation costs add to the marginal cost of exporting, meaning that the firm exports less abroad than it produces domestically. Given this fact, the marginal revenue in each firm's export market is higher than in its own. This is coupled with the fact that the marginal cost of exporting is also higher than the marginal cost of production for indigenous consumption for each firm. Therefore, the marginal revenue of exporting can equal the marginal cost of exporting at positive output levels in *both* markets. Since this is true for both firms, cross-hauling develops. The question remains if whether or not the two-way trade is actually dumping. Given the high elasticity of exports that each firm faces (due to symmetry), each firm has a smaller markup over marginal cost on its exports than on the output for its own market. Thus, the export price is less than the domestic price in both

markets. This is reciprocal dumping. It stems from firm symmetry and oligopolistic rivalry.

Brander and Krugman also explore the welfare effects of positive transportation costs. If there is reciprocal dumping, then it appears on the surface that trade is rather inefficient and welfare decaying. Both firms are incurring transportation costs with exporting, and both firms are exporting identical goods into each other's markets. Brander and Krugman find that at initial prohibitive transportation costs, there is no trade, and a slight reduction in transportation costs from this level leads to lower welfare. The intuition is that the decrease in the marginal cost of exporting is a gain for firms. Secondly, increased trade leads to increased consumption, which is also a gain. But these gains are negligible when compared with the loss that a firm faces from a higher level of imports entering that firm's native market. This increased level of imports results in lost domestic production. Therefore at high transportation costs, there is a net welfare loss.

David Weinstein (1992) pursues the dumping issue further. He extends the Brander-Krugman reciprocal dumping model by allowing for the existence of markets with different degrees of competitiveness. Weinstein answers the question posed above with respect to differing numbers of firms in the two markets.

Brander and Krugman showed reciprocal dumping occurring between two firms due to transportation costs, oligopolistic rivalry, and identical inverse demand functions in both markets. Allowing n to represent the number of domestic firms and n^* to be the number of foreign firms, Brander and Krugman showed reciprocal dumping in a situation where $n = n^* = 1$. Weinstein uses the Brander-Krugman reciprocal dumping model and all of its assumptions to show that intra-industry trade still occurs for all values of n and n^*. Thus, reciprocal dumping continues to hold as long as production and transport costs to the other market are less than the price in that market. This is simply rent-seeking behavior that takes place among all firms with some degree of market power.

Notice that dumping in actuality is nothing more than rent-seeking behavior. The reason firms price discriminate is to capture additional surplus that would not be recognized by charging the same price in both markets. If a domestic firm wishes to increase production to try to increase sales and profit, the flooding of goods into the home market will lower the price of output. However, if the firm increases its exports to a

foreign market, the price is depressed in the foreign market and not in the domestic country. But in the absence of trade barriers, this action can happen both ways. The foreign firm can pursue the same type of rent-seeking behavior.

Weinstein's additional contribution to the literature is that he moves away from the assumption of an identical number of firms in each market. He alters the model by assuming that more firms exist in the domestic nation than in the foreign country, making the domestic nation more competitive. The foreign market, being less competitive, will have relatively high prices for output. This allows the domestic firms to export and dump goods into the foreign market. However, the higher degree of competition in the domestic market results in domestic prices of output that are too low, and consequently foreign firms do not find it profitable to export goods to the domestic market. Therefore, the dumping is only one-way, or what Weinstein refers to as *unilateral dumping*.

2.1.B. Horizontal Integration as Foreign Direct Investment:

While this practice of intraindustry trade continues to a large degree, there has also been a significant increase in foreign presence in the United States. This increased presence is not so much through imports, but through multinational firms. Similarly, the United States invests capital in other nations. This *foreign direct investment* (FDI) provides a nation with an alternative to exporting. A multinational is a situation in which the investing firm, for example a firm in the United States, opens or buys a firm in another nation. The investing firm in the United States would best be described as a "planning firm," while the firm in the foreign country serves to produce locally for residents of that nation. The obvious advantage of a firm becoming a multinational is that it avoids transportation costs by not exporting. The firm captures some of the foreign market through the operation of its plant abroad.

Fumio Dei (1990) extends the Brander-Krugman model of reciprocal dumping by allowing for the presence of such *multinational corporations (MNCs)*, allowing the formation of MNCs as an alternative to exporting.

The model and initial assumptions Dei uses are the same as those first presented by Brander and Krugman in their first work on reciprocal dumping. Dei's approach to the operations of the MNC are the same as those noted above. The headquarter firm incurs only fixed costs, such as management and marketing costs, while production costs

(i.e., variable costs) are incurred by plants abroad. Plants can be relocated abroad, but the headquarter "planning" firm remains in the country of origin.

The firms (home and foreign) can only pursue one strategy at a time. That is, they must choose to export only (production from plants abroad equals zero) or become a multinational. If a firm decides to become a multinational, it ceases all exporting to avoid transportation costs and simply supplies the foreign market locally through its plant in that country.

When one firm opts to become a multinational, its marginal cost of supply to the foreign market will be less than its marginal cost of exporting to that market. This is of course due to the avoidance of transportation costs which are involved in exporting. If the other firm chooses not to multinationalize, then its marginal cost of supplying the other market does not change. This reduction in marginal cost raises profits in Cournot duopoly. Because both firms can become MNCs, both will do so. Hence, positive transportation costs and Cournot behavior lead to *mutual penetration* by MNCs.

Dei next turns to the issue of market size and MNC profitability. The MNC has two areas of revenue net of variable costs: some level R, which is the home firm's revenue net of variable costs in the home market, and R^*, which is the home firm's revenue net of variable costs in the foreign market. Allowing F to be fixed costs, home firm profit would then be $\pi = R + R^* - F$. A large domestic market leads to a large decrease in R, while at the same time a relatively small foreign market yields a small increase in R^*. The rationale is as follows: if a foreign firm penetrates the large domestic market, that firm will lose market share to the foreign firm's plant (which recall is producing in the domestic market, avoiding transportation costs). Thus the large domestic market is being invaded by the rent-seeking foreign firm. Alternatively, the domestic multinational benefits from increased presence in the foreign market, producing in that market to similarly avoid transportation costs. But if the size of the foreign market is relatively small, the gains to the domestic multinational will be small as well. Dei finds unsurprisingly that total welfare rises with the mutual penetration of MNCs, largely because both firms as MNCs can escape wasteful transportation costs, which in turn leads to an increase in global welfare.

If a firm decides to become a multinational, it must decide which is better: to open a new plant or buy out a competitor. Of course, both options may not be available to a firm wishing to become a multinational. If a firm decides to open a new plant abroad, this is called *greenfield investment*. This would most likely be the popular choice for this firm with respect to the residents of the nation in which a new plant is to be opened. A firm that opens a new plant will most likely hire local workers at the production level, hence providing new jobs in that nation.

This is not always embraced by foreign residents however. In Japan for example, outsiders are not always welcomed, and are labeled *gaijin*, which literally means "foreigner."[1] Russia has seen significant difficulties in luring foreign capital into its country. Upon perestroika economic reforms in 1985, joint ventures and foreign direct investment were highly sought after by reformers such as Premier Mikhail Gorbachev. To be sure, skepticism of Western firms and the inefficiencies of Soviet and Russian capital kept foreign investment at bay. But the hard-line Communists took the same point of view as some of the Japanese. The Soviet government did not want their country's assets to be purchased by outsiders from the West. In other cases however, the firm is seen as it is: a provider of jobs for local residents, thus earning the goodwill of the local government.

On the other hand, a firm may be seen as an enemy to competition. If a firm merges with a foreign competitor, this type of *horizontal integration* inhibits competition. As competition diminishes, the monopoly power (perhaps measured by market share) of existing firms likely increases, and there is a high probability of restricted output and higher prices. This would of course be significantly unpopular among that nation's citizens. There are significant issues in this case with respect to the Sherman Antitrust Act of 1890 and the Clayton Act of 1914.[2]

Joseph Farrell and Carl Shapiro (1990) analyze the effects of one firm acquiring another firm's assets in a concentrated industry. Specifically, they show the effects on individual firm profit and price with the change in asset ownership. Farrell and Shapiro

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[1] Edith Hill Updike and Keith Naughton, "Ford Has a Long Haul at Mazda," *Business Week*, 7 October 1996, 112.

[2] Information concerning these two pieces of antitrust legislation can be found in any business law textbook, such as Smith, Mann, and Roberts, *Business Law and the Regulation of Business*, 4th ed., (West Publishing Company, 1993), 1005-1023.

examine this transfer of ownership in terms of stock purchases, and wish to observe the effects of such share purchases. They present their model with two firms, Firm 1 as the acquirer and Firm 2 as the seller, and an unidentified number of j other firms. Farrell and Shapiro shows Firm 1's profit function as $\pi_1 + \alpha\pi_2$, where α is Firm 1's ownership stake in Firm 2. Farrell and Shapiro also state a precondition in that this level of ownership is assumed to be small, in that Firm 1 cannot influence Firm 2's decision making with respect to managerial control. Firm 1 chooses output level x_1 to maximize this profit function, whereas all other firms choose x_j to maximize π_j for all $j > 2$. Farrell and Shapiro correctly state that Firm 2's objective function is not clear without introducing other conditions. If shareholders of Firm 2 own zero stock in Firm 1, then these shareholders will only want to maximize π_2 with respect to x_2. Conversely, shareholders of Firm 1 will want to set x_2 such that it maximizes Firm 1's profit function above. But the central point remains in Farrell and Shapiro's precondition. If Firm 1 does not purchase enough of Firm 2 as to exercise managerial control, then Firm 2 will likely maximize π_2 in terms of x_2. Shareholder interest in Firm 1 would have to be formally modeled. Lastly, all firms behave Cournot in that they do not collude, and each firm takes all other firms' output as given.

Farrell and Shapiro hypothesize that as the ownership stake increases, then Firm 1 will lower its output in favor of Firm 2 to increase its financial stake in Firm 2. As a response, all other firms (including Firm 2) will increase output. Farrell and Shapiro build on Reynolds and Snapp (1986) by stating that an increase in α lowers total equilibrium output, raising price as a result. This would mean that Firm 1's reduction in output outweighs all other j firms' increases in output. Farrell and Shapiro use total differentiation to prove this result. Firm 1's behavior may then be seen as anticompetitive, since it results in output contraction and higher prices.

The effects on firm profit are not surprising. Firm 1 will see reductions in profit since it is reducing its output. However, Firm 1 is reducing its output in order to augment Firm 2's profits, which will in turn benefit Firm 1. This provides for ambiguity in terms of total shareholder profit. In other words, $\pi_1 + \alpha\pi_2$ may rise or fall. In addition, Farrell and Shapiro call on findings by Salant, Switzer, and Reynolds (1983) by stating that

mergers in Cournot oligopolies may not be profitable due to all other firms increasing output as the merging parties act to restrict it. This also leads to the ambiguity of Firm 1 shareholder profit. Conversely, the profits for all firms $j > 1$ will rise with increases in α. This is again due to output expansion by all firms other than Firm 1.

There is a caveat provided for assured Firm 1 profitability however. Firm 1 will find it profitable to purchase shares of Firm 2 if and only if Firm 1 is relatively small. The authors admit that in reality, the opposite is often seen. They proceed further in stating that if Firm 1 were larger than Firm 2, any stock purchase would only be profitable if Firm 1 gained managerial control over Firm 2. They predict that Firm 2 would lower output in this case, which will benefit Firm 1. Farrell and Shapiro do not formally pursue this hypothesis further.

Notice that one method of forming a multinational will increase competition, while the other may actually hamper it. When a firm tries to engage in horizontal integration, which is merging with a similar firm at the same stage of the production process, it may raise antitrust concerns. A firm that enjoys market power has the ability to charge a significant markup over marginal cost. The Antitrust Division of the United States Department of Justice analyzes potential mergers and acquisitions. When a firm obtains seventy-five percent market share, this raises tremendous anticompetitive concerns. The firms involved could possibly be in violation of the Clayton Act, which makes certain mergers illegal due to the harmful effects they would have on competition. Therefore, even if a firm would like to merge with another, it could perhaps never take place due to government concerns of violation of antitrust legislation.

2.1.C. The Literature and Chapters Three and Four:

The literature addressed above motivates the next two chapters of this dissertation. The third chapter presents horizontal integration taking ownership exogenously. This essay is pursued in spite of the antitrust concerns previously mentioned. However, the fourth chapter illustrates ownership in an international duopoly taking real world concerns such as antitrust legislation into account. This endogenous treatment of ownership in the horizontal integration model utilizes Kuhn-Tucker programming given certain constraints to ownership.

2.2. Vertical Integration:

2.2.A. Description:

Firms can obtain a presence in another nation not only through exports, greenfield investment, or horizontal integration. Firms can also significantly influence their competitor's behavior as well as increase profits through *vertical integration*, merging with a firm at a *different* stage of the production process. For example, suppose an automobile manufacturer wishes to merge with a firm that produces steel. Steel is an important input in the production process for automobiles. In terms of notation, the automobile manufacturer would be called the "downstream" firm, while the steel manufacturer would be the "upstream" firm. This type of vertical integration is called backward vertical integration.

There are several reasons why a firm would want to engage in this type of integration. First of all, it provides an avenue for the aforementioned presence in a foreign market. For example, a downstream firm in the United States may wish to integrate with a supplier in Mexico. This action would allow the U.S. firm to have a presence in Mexico and indirectly influence competition in both the upstream and downstream markets. Secondly, supply disruptions can cause instability in the downstream firm's long-range planning. By merging with a supplier, the downstream firm may not be able to eliminate supply disruptions, but may at the very least reduce their impact. This is due to the fact that with one integrated firm doing production planning, rather than two separate individual firms, supply disruptions could be forecasted in advance for the downstream division of the integrated firm and it could react accordingly. A third reason for backward vertical integration is that the two divisions of a vertically-integrated firm tend to have conflicting profit maximization goals. An input supplier prefers high prices for its output. An upstream division's output is of course the downstream division's input. The downstream division does not want high prices for its inputs, as this leads to high production costs. Thus by integrating, some type of joint profit function could be maximized, which would benefit the vertically-integrated firm as a whole.

2.2.B. Foreclosure Issues:

Janusz Ordover, Garth Saloner, and Steven Salop (1990) present a seminal paper concerning vertical integration. They first address the common fallacy associated with vertical integration. It has past been accepted that vertical integration is anticompetitive by its very nature. If a firm merges with an upstream supplier, the newly-integrated firm will choose not to supply the input to the competitors of the downstream division. This reduction in available supply will increase the price of inputs to the unintegrated downstream firms, due to less competition faced by the remaining unintegrated suppliers. The downstream competitors are hence foreclosed from the market. The restriction in downstream output increases the price of the final product. Of course, the profits of the vertically-integrated firm have the potential to rise, given that the integrated firm has a source of input supply. The integrated firm captures a greater market share with the foreclosure of downstream rivals.

The fallacy lies in the assumption that once a firm integrates with a supplier, the upstream division will choose not to supply the input to competitors. Additionally, vertical mergers do not necessarily imply anticompetitive behavior. Robert Bork (1978) states that "…in the absence of a most unlikely proved predatory power and purpose, antitrust should never object to the verticality of any merger…. Properly drawn and applied horizontal rules are all that we need."[3]

Ordover, Saloner, and Salop (hereafter OSS) also note six common objections to foreclosure theory.:

1. Vertical mergers do not necessarily mean lower input supply to competitors.
<u>Reason</u>: The integrated firm will reduce its demand for inputs produced by unintegrated suppliers. The act of the downstream firm obtaining the input from its upstream division does not mean that the downstream firm will produce more than before. Hence its share of the upstream demand may be no different after integration. The supply relationship in the production process has changed.

2. Foreclosure of downstream competitors may not be profitable.
<u>Reason</u>: If the upstream division does not sell the input to competitors, then that division loses sales revenue. This loss may exceed the increase in downstream division profits

[3] Robert Bork, *The Antitrust Paradox*, (New York: Basic Books, 1978), 245.

from integration. Given this, it may not be in the best interest of the integrated firm to foreclose downstream competitors from input supply.

3. It may not be true that unintegrated input suppliers raise input prices if the integrated firm does not sell on the open market.

Reason: Lack of competition does not necessarily result in higher input prices. This is due to the fear the unintegrated input suppliers have in that downstream firms will begin to produce the input on their own. This is a primary reason why the oil cartel OPEC does not keep the price of oil high for long periods of time. If it were to do so, then buyers of oil would seek to increase their own supply through increased exploratory drilling, or finding alternative energy sources. Even if a downstream firm cannot produce the input on its own, higher input prices would cause them to reduce their demand for these inputs. Input suppliers may see their product as being rather elastic to downstream buyers.

4. Integration may cause counterintegration.

Reason: If initial integration by two firms yields cost advantages for the new merger, then other downstream firms will have the desire to integrate with other remaining suppliers. This would take away the cost advantage of the initial integration.

5. Initial attempts at vertical integration may fail, and no merger may take place.

Reason: If upstream firms know that they will have increased market power upon integration occurring, then each upstream firm may hold out. A downstream firm may not be able to provide a bid attractive enough to compensate an upstream firm from forgoing this chance at increased market power. If all upstream firms feel this way, each one will continue to hold out for a higher bid. In fact, this behavior could lead to the possibility that no merger takes place to begin with.

6. Anticipated foreclosure may lead other downstream firms to bid initially for the upstream firm.

Reason: If a downstream firm anticipates the danger and consequences of being foreclosed, it may choose to enter the bidding for the upstream firm in question. This would yield the benefits of integration to this firm, and not the initial bidder. With these objections and open questions in vertical integration theory, OSS develop a theory of equilibrium vertical foreclosure.

OSS model a two upstream-two downstream successive duopoly. The upstream firms provide equal shares of the homogeneous input to the downstream firms. These downstream competitors produce differentiated products in Bertrand competition, and have equal market shares. With respect to Bertrand competition, OSS remark that increases in a rival's input cost will increase both the equilibrium prices and the firm's profits around stable Bertrand-Nash equilibria. They also state that an industry-wide cost increase would be more likely to increase firms' profits rather than a unilateral increase. This is due to the notion that there will be a larger change in equilibrium prices as opposed to what occurs unilaterally.

OSS denote the two upstream firms as U1 and U2, and the two downstream firms as D1 and D2. Suppose D1 merges with U1, and forecloses D2 from the input market. U2 now has monopoly power in the input market. It will increase the input price to that level which maximizes monopoly profits. If D1's profits increase with an increase in its rival's costs, then the integrated D1 observes higher profits. D2 on the other hand will have lower profits due to the increase in input price. If there are no efficiency gains from vertical integration, societal welfare will fall, and D1's initial integration is deemed anticompetitive.

OSS approach the vertical integration problem in a four-stage Bertrand game, which is solved through backward induction. In the first stage, the two downstream firms have the opportunity to merge with one of the upstream suppliers. In the second stage, the input prices are determined. If downstream firm D1 merges with upstream U1, this vertically integrated firm is now expressed as F1. With the integration of D1 and U1, D1 will now be able to obtain the input to production at marginal cost, and not be subject to a markup. With respect to downstream firm D2, OSS illustrate three different cases of input pricing. In case i), F1 and U2 will simultaneously set the input prices they will charge in supplying the input to U2. With case ii), F1 chooses not to supply D2 at all. In the absence of inferior inputs, U2 will have monopoly input pricing power over U2. Lastly, in case iii), F1 acts as a first-mover in input pricing. Specifically, it announces a price to D2 before U2 specifies its input price. Notice that in moving from case i) to case iii), F1 has increasing control over the input price faced by D2.

With respect to Stage 3, D2 has the opportunity to bid for the unintegrated supplier, U2. D2 makes its countermerger decision based on the input price it faces from Stage 2. In Stage 4, the downstream prices are chosen, given input prices.

One of the key questions of this model is whether or not D2 will counterintegrate. In solving the model, OSS analyze the *stand-alone profits*. In other words, the summation of profits earned by an unintegrated U2 and D2 are compared to the profits they would make as a vertically-integrated firm. If the profits from remaining separated are higher than profits from integrating, U2 and D2 will logically remain apart. Allowing c_2 to denote the input price charged by U2, and m to be the marginal cost of the input, the stand-alone profits are expressed as $\pi^s(c_2) = \pi_{D2}(c_2) + \pi_{U2}(c_2, m)$. In differentiating these stand-alone profits with respect to input price c_2, and evaluating around $c_2 = m$, OSS state in Proposition 1 that if the initial equilibrium is stable, a small increase in input price above marginal cost to D2 increases the stand-alone profits. Thus, there is a range where D2 will not be able to make an acceptable offer to U2 and counterintegrate. Eventually however, as the markup over marginal cost increases, D2 will have lower profits, and this will cause stand-alone profits to fall. U2 profits will not be large enough to counter lost profit from D2 due to the higher input price.

In detailing Stage 2, OSS identify each case in turn. With case i), given that F1 and U2 set input prices simultaneously, Bertrand competition will force each firm to undercut the other, meaning that the input price will be set at marginal cost. For case ii), U2 will charge the monopoly input price to D2 in the absence of an alternative inferior input. If there is an inferior input available, then D2 will get an input price below this monopoly level.

Case iii) is the interesting scenario presented by OSS. F1 acts to attempt to contain U2's input pricing power. F1 commits to an input price that makes the stand-alone profits (denoted above as π^s) equal to a "benchmark" level of profits. At this benchmark level of profits, no integration takes place between D2 and U2. F1 obtains the input at marginal cost, whereas D2 must pay some markup above marginal cost. The unintegrated downstream firm, D2, is worse off after the D1-U1 merger. D2 is faced with a higher input cost.

However, D1, the downstream division of F1, is also worse off after the merger. While gross profits from the merger increase due to the cost advantage, D1 had to bid to purchase U1. Consequently, both downstream firms are worse off after the D1-U1 merger. The fear of being foreclosed causes both firms to try and capture U1. As a result, the rents earned through foreclosure are essentially lost in the bidding process. The winners in this model are the upstream firms, specifically U1. First of all, U1 receives the winning bid of D1. The profits from F1 will be greater than the stand-alone profits that U2 represents, due to the pricing strategy imposed upon D2. Recall, the entire basis of F1's input pricing strategy is to prevent D2 and U2 from counterintegrating.

With respect to quantity competition, OSS find that U2 and D2 will always merge in the face of a U1-D1 merger. This is due to the fact that stand-alone profits unambiguously fall with increases in the input price. Recall that the input price is the basis of whether or not counterintegration will take place. Thus Proposition 2 notes that if the downstream firms compete in quantities, then no vertical merger is the only equilibrium that prevails. If there will always be counterintegration upon vertical integration by U1 and D1, firms waste resources through their bids for each upstream firm.

Even though the work on vertical integration by OSS represents a seminal paper in the field, it is not without certain problems regarding the input prices faced by F1 and D2. With respect to the input pricing strategy by F1, David Reiffen (1992) offers comments on the effects of vertical integration on downstream prices. Specifically, Reiffen claims that if a firm is able to commit to an input price, vertical integration is not necessary to ensure higher downstream prices. For example, in the OSS equilibrium, Reiffen states that it would be profitable for U1 to undercut U2's input price to D2, since U2's input price is above marginal cost after U1-D1's integration. OSS stipulate that F1 would not undercut U2's input price. Reiffen's problem with the work of OSS is their use of statics and not dynamics. In the OSS static framework, firms cannot necessarily react if they do not observe the actions of the other player (which is not an unrealistic statement in a static model). In reference to input price competition, OSS claim that U1 would expect U2 to lower its input price if U1 were to reduce its input price. Reiffen does not believe this intuition in a static model, regardless if the integrated firm is

farsighted with respect to input price competition. To correct this problem, a dynamic framework is needed. Reiffen models the problem concerning just the two downstream firms. If the downstream firms take the actions of their rivals into account, the game is simply a Stackelberg leader game. The sequential pricing game assumes price commitment.

Reiffen's comment was not without a reply from OSS (1992). OSS claim in their reply that the results from their previous work in fact do not depend on a commitment by F1. They state that firms which become vertically integrated will change their incentives regarding input price-cutting in the input market. Their results are based on a concept that vertically integrated firms will behave differently from unintegrated firms with respect to input supply to competitors. Reiffen claimed that F1 would not be able to commit to foreclose D2 from input supply, leaving U1 to be a monopolist in the input market.

OSS first respond to the setting of upstream prices. OSS freely admit that their first work did implicitly introduce dynamics in the input pricing stage. But they continue by claiming that input prices may not be set instantaneously. If U2 quotes a price to D2, D2 could then go to F1 and negotiate a lower input price. With this lower input price, D2 could then go back to U2 and bid the price down even further. This would continue until one of the firms (U2 or F1) decide it is no longer profitable to continue bidding. OSS claim that if F1 knows that this is the process in the input pricing stage, then F1 will not undercut U2 to begin with. F1 will hence stand ready to supply D2 at an input price that forestalls D2's possible counterintegration.

In their reply, OSS model the input pricing stage as a descending-price auction. F1 and U2 bid for the business of D2. They find that the unique equilibrium that results is that F1 drops out of the bidding at the input price which forestalls counterintegration by U2 and D2. D2 is supplied by U2 at this input price. The incentive for F1 to stay in the market and bid for D2's business is again based upon F1's desire not to grant monopoly power to U2. It is the process of F1 threatening to stand by ready to supply which results in its success in raising rival D2's costs. It is not F1's ability to commit to that price. Thus, vertical foreclosure of D2 by F1 in the input market can lead to the increasing of input and downstream prices. These results are not robust in the case of

many upstream firms, which Reiffen points out. But OSS argue that their results will hold as long as input prices are negatively-correlated with the number of upstream suppliers (which is standard). The very nature of incentives of the upstream firm change upon integration, and these changes in incentives will allow the equilibrium result to occur, despite the lack of commitment power by F1.

The original work by OSS and their ensuing reply to Reiffen's comment is still not without a fundamental flaw. OSS assumed that upon vertical integration of D1 and U1, this firm (F1) would obtain the input to production at marginal cost. Unintegrated downstream rivals would be faced with higher input costs. This is not accurate. When two divisions are integrated, the upstream division usually supplies the downstream division at a discounted input price. This input price is still marked above marginal cost however.

James Hamilton and Ibrahim Mqasqas (1997) also pursue input pricing strategy, but they correct for this input pricing problem mentioned above. Particularly, they address something known as *strategic internal transfer pricing*, in which the downstream division of a vertically integrated firm does not necessarily obtain the input to production at marginal cost. Bork (1978) noted that vertically integrated firms would not receive the input to production at marginal cost. Specifically, he states that "the firm will not, as is frequently suggested, sell to its own retail subsidiary for less than it sells to outsiders, unless the efficiencies of integration lower the cost of selling to its own retail unit."[4] In other words, a vertically integrated firm must charge itself the same price for the input to production that that input would have brought on the open market. Bork goes on to say that "it is impossible for a firm actually to sell to itself for less than it sells to outside firms because the real cost of any transfer from the manufacturing unit to the retailing unit includes the return that could have been made on a sale to an outsider."[5] For competitors to claim that their vertically integrated rivals are obtaining inputs at cost while they are paying some markup above cost is not correct. Thus it appears that this is a flaw in OSS. Although, it should be noted that OSS suggested that vertically integrated firms may use some input price other than marginal cost.

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[4] Bork, 228.
[5] Bork, 228.

Aside from taking into account strategic internal transfer pricing, the crux of the work of Hamilton and Mqasqas is also a model of foreclosure. They stipulate that manipulation of the internal transfer price of the input to production may serve an integrated firm in preventing counterintegration by its rivals. The work of Hamilton and Mqasqas contributes much to the literature, and their work is presented in varying forms (heterogeneous and homogeneous input assumptions). The model presentation, key results, and conclusions follow.

With respect to integration strategy and foreclosure, Hamilton and Mqasqas follow the model of OSS with a four-stage game. However, the integration decisions of the firms (an i pair and a j pair) take place in different stages as opposed to the same stage. The retailers (downstream firms) produce differentiated products. The intermediate product (manufacturer product; upstream product; input) can be either homogeneous or heterogeneous. In Stage 1, the i pair decide if they should vertically integrate. If the pair decide to integrate, then an input pricing strategy is pursued in the second stage. In Stage 3, it is the j pair that decide upon integration or remaining apart. They base this decision on what took place between the i pair in Stage 1. If the j pair decide to remain apart and forego integration, the j-upstream firm will set a price for the input. Lastly, Stage 4 is a market equilibrium from the decisions in the preceding stages. The firms pursue Bertrand competition in retail (hence downstream) prices.

In Stage 2, Hamilton and Mqasqas propose that the integrated i pair should not set the internal transfer price to marginal cost. They deem this strategy as "direct" since the integrated i pair is not necessarily influencing the prices of another firm. It is direct in that the vertically integrated firm is pursuing this strategy with respect to its own transactions between the upstream and downstream divisions. Specifically, the vertically integrated i pair sets the transfer price to maximize overall firm profit in Stage 2. This choice of input price is deemed strategic because the vertically integrated firm is forward-looking. In other words, the i firm anticipates the reactions of the j pair of firms in the setting of i's input price. The advantage of strategic internal transfer pricing is that i firm profits will increase by preventing counterintegration of the j pair of firms. Even though the j pair do not integrate, they are not foreclosed from the market.

Hamilton and Mqasqas also present an analysis of a vertically integrated firm trading for the input in the open market. In other words, if there is an open market for the input to production, then the i firm may decide to sell some of the input to nonintegrated downstream competitors. (This was also mentioned in the original work by OSS. They mentioned that the integrated firm F1 may decide whether or not to supply the input to its downstream rival.) In this case, the i firm strategically chooses the quantity of the input that would maximize the integrated firm's profits.

Upon the i firm selling the input on the open market (without strategic transfer pricing), the increased input availability brings down the open market input price. This price is reduced to the level in which counterintegration by the j pair of firms does not take place. Thus, open market trading of the input can result in forestalling integration as well. However, Hamilton and Mqasqas note that profits of the integrated firm with open market input trading are not as high as under strategic internal transfer pricing.

Suppose the i firm can pursue a combination strategy of open market trading and strategic internal transfer pricing. In this case, it would set a transfer price between divisions, and trade some level of input in the open market to maximize overall firm profit. In the case of homogeneous inputs, the subgame perfect Nash equilibrium is the i pair vertically integrating, while the j pair remain unintegrated. When comparing this combined strategy to one of simply using strategic internal transfer pricing, the i firm achieves higher profits upon selling the input in the open market.

The basic conclusion of Hamilton and Mqasqas is that vertically integrated firms in a linear duopoly model will set transfer prices above marginal cost and would actively engage in trading the input to downstream competitors. These two strategies will be more profitable than any proposed strategies by OSS.

In another work co-authored by Soo Bock Lee, Hamilton (1986) analyzes the issue of vertical mergers, foreclosure, and economic welfare. It is thought by some that vertical integration is undoubtedly welfare-reducing if it results in market foreclosure. If foreclosure leads to higher prices, then from the standpoint of the consumer, welfare would indeed be lowered. However, total welfare effects of vertical integration should be pursued. Vertical integration may lead to increased efficiency, which actually lowers costs, even perhaps in the presence of foreclosure. The primary motivation for Hamilton

and Lee's work deals with analyzing this foreclosure and welfare situation in a model of vertical mergers.

Hamilton and Lee measure foreclosure in two ways: absolute foreclosure and relative foreclosure. Absolute foreclosure is when a vertical merger results in a reduction of output of a nonintegrated firm. Relative foreclosure results if a nonintegrated firm's market share is reduced. Notice the distinction. Either measure of foreclosure is typically deemed harmful to competition by the Courts.

The model is as follows: there is a final product produced by two homogenous Cournot firms. The firms produce output with a fixed proportions technology with constant marginal costs. Each unit of output requires one unit of some key input, while other inputs in the production of the final output are available in perfectly elastic supply. The key input is produced by both a dominant firm and a competitive fringe. The dominant firm produces the input at a constant marginal cost, which is less than the marginal cost of the competitive fringe. Vertical integration is presented as the dominant upstream firm merging with one of the downstream firms, leaving the other downstream firm as a nonintegrated competitor. Hamilton and Lee call the newly integrated firm a vertically integrated dominant firm (VIDF). This VIDF maximizes profits with respect to its downstream output and key input. Foreclosure and economic welfare effects are illustrated using linear demand and entry functions.

Upon finding the postmerger equilibrium values, Hamilton and Lee discover that the vertical merger always increases final output. This is due to the fact that either the VIDF or the nonintegrated downstream competitor or both obtain the key input at a lower input price after the merger. The input price is lowered given the presence of the competitive fringe input producers. Thus the Hamilton-Lee model presents a situation in which vertical integration will lead to an increase in economic welfare. Input supply from the competitive fringe is unchanged after the merger, hence no absolute foreclosure exists. (In the short-run, fringe firm supply is fixed.) However, the fringe is relatively foreclosed because the market share of each of the firms in the fringe falls. The reason for this foreclosure is that the merger increases final output. The final output of the downstream competitor is dependent upon fringe supply, and the presence of a fringe supply determines the postmerger key input price.

Moreover, the results of the model show that the merger reduces the nonintegrated competitor's final output. Additionally, this firm is also relatively foreclosed. Interestingly enough, the VIDF purchases some of the key input from the competitive fringe upstream suppliers. It cannot produce enough of the key input itself to sustain its final output requirement. Recall that the output of the competitive fringe suppliers is perfectly inelastic in the short-run. If the VIDF's production of the input is less than its production of the final good, it must purchase some of the input from nonintegrated upstream suppliers. The integrated firm can purchase some of the key input at a price which is higher than its marginal cost of input production. Doing so would lower its final output and push upward pressure on the output price. Input supply from the fringe is fixed, hence the VIDF must produce some of the input itself. If the VIDF purchases some of the key input, then this is less input that is available for the nonintegrated downstream competitor. As a result, this firm lowers its output after the merger. The fact that the dominant upstream firm is part of the integrated firm and produces some of the input for that firm, means that each fringe firm has a smaller share of the total key input market after the merger. The VIDF operates in two markets at the same time. The VIDF and the competitive fringe do not compete for the business of the remaining unintegrated downstream producer.

The main conclusion of Hamilton and Lee is that foreclosure does not always lead to a reduction in economic welfare if that welfare is a function of the total output of the final good. As a result, the Courts should look more carefully for signs of anticompetitive behavior that is deemed harmful to competition. Looking at foreclosure alone may not be enough. Vertical mergers may lead to increased efficiency. This increased efficiency would not be achieved if the Courts prevented the merger from happening in the first place, for fear of possible foreclosure of nonintegrated firms.

2.2.C. Other Approaches to Vertical Integration:

Differing characteristics of vertical integration have been pursued. The situation has been approached from different aspects with respect to the input pricing strategies mentioned above, as well as relative competitiveness of the upstream market. Michael Riordan (1998) deals with vertical integration by a dominant firm. Riordan's criticism of previous work concerns certain considerations of game theory. Additionally, Riordan

claims that welfare effects are not easily determined if mergers have efficiency benefits and anticompetitive characteristics.

Riordan's model consists of a dominant firm and a competitive fringe. All firms produce a homogeneous good. The downstream good requires a fixed input, deemed capacity. This capacity can be thought of as a type of capital good. Production of the downstream good requires both capacity and variable inputs. Fringe short-run variable cost is an increasing function in output with increasing marginal cost. The dominant firm is such because it has a cost advantage in the variable input (expressed as a fraction of per unit final output). Notice then that Riordan's contribution to the literature is an alternative model of the vertical integration problem. One firm is assumed to have a cost advantage over all others. The dominant firm maximizes profit with fringe production activity taken as given.

The model flows accordingly: the dominant firm chooses its capacity; then the fringe firms will enter the industry; the dominant firm chooses its output level; and lastly, the fringe firms choose their output levels.

In solving the model, Riordan concludes that vertical integration pursued by the dominant firm is anticompetitive. This is because both the output price and input price are positively-correlated with the degree of vertical integration. The marginal cost of production is lower for the dominant firm than for the fringe. Given this, the total market production cost would be less if the dominant firm were to take on a greater share of the market. With increased vertical integration (a larger capacity taken on by the dominant firm), the dominant firm may be more efficient than the competitive fringe. With increased capacity by the dominant firm, the fringe is foreclosed due to higher capacity prices (because of lower availability). However, the dominant firm tends not to efficiently use its capacity given its market power, which arises from its cost advantage. Therefore, fringe foreclosure outweighs vertical integration by the dominant firm, hence prices increase.

Y. Joseph Lin (1988) writes a brief note on oligopolies and vertical disintegration. The motivation for his work was brought about by previous work tending to focus on monopolistic or competitive market environments. Lin's model is made up of two manufacturers, named x and y who produce heterogeneous products. Lin describes two

alternatives firms face for product distribution. In one instance, the firms can sell their products themselves, hence acting as a vertically integrated firm. In another, the firms can distribute their products through independent sellers, known as vertical disintegration. Lin assumes zero marginal and distribution costs for simplicity. With these two possible methods of distribution, there exist four possible vertical relationships: x and y can both be integrated or disintegrated, or x can be disintegrated while y is integrated, or vice-versa. With respect to consumer behavior, consumers buy from x or y or not at all. Regarding choice, consumers purchase x if the difference in their valuations of x and y is greater than the difference in the prices of x and y.

The model is solved as a two-stage Nash game, with backward induction used to find the subgame equilibrium. In Stage 1, the optimal vertical relationship is found. In Stage 2, x and y profits under each of the four vertical relationships are found. The optimal vertical relationship is based upon the four profit possibilities.

Lin finds two possible Nash equilibria: both x and y disintegrating or both integrating. However, Lin finds that the equilibrium with both firms integrating is not stable. The payoff for both firms disintegrating is greater than the payoff for both firms becoming integrated. As a result, either firm has an incentive to deviate from integrating. Hence the only stable Nash equilibrium is when both firms are not integrated.

The intuition is that there is a greater inelasticity (greater nonresponsiveness) of quantity to manufacturer (wholesale) price with respect to non-integration. If an integrated manufacturer were to increase the retail price of its output, its sales obviously will fall given the law of demand. If the manufacturer were unintegrated and increased its wholesale price by the same magnitude as in the first instance, the marginal cost of the distributor of the firm's product would increase by the same amount. If the distributor in turn increased the retail price, the distributor's sales as well as sales of the manufacturer would fall. Lin asserts that the distributor would not increase the retail price by the same amount as the manufacturer. The distributor would increase the retail price by an amount where the marginal revenue would increase by the same magnitude as its increase in marginal cost. Therefore, the retail price would increase by less than the increase in the wholesale price given a marginal revenue curve that is steeper than the demand curve. The manufacturer's sales still decrease with the increase in wholesale price, but by less

than in the integration situation. What is true for one manufacturer is of course true for the other. Hence, both firms will be unintegrated. Notice then that with an oligopolistic market structure, Lin finds that the firms being unintegrated can lead to higher prices and higher profits. Much vertical integration literature involves integration leading to higher prices and higher profits of integrated firms.

Michael Salinger (1988) revisits the notion of an integrated firm selling the input in the upstream market. He also examines how the effects on the input market affect the output market. Salinger approaches the problem from the classic question that always surrounds vertical integration literature: Does vertical integration lead to foreclosure? Specifically, if a producer becomes vertically integrated, it can choose either to sell the input on the open market or not, thereby foreclosing a competitor from a source of input supply. This question was posed in the core work by OSS described above. In their paper, OSS found that vertical integration in Bertrand competition in the output market can lead to vertical foreclosure of a downstream rival. In their context of foreclosure, the integrated firm did supply the input to its competitor, but a higher input price was charged.

Salinger's model consists of both homogeneous inputs and outputs. Both are produced with constant returns to scale, and the downstream product is produced with fixed-coefficients technology. The vertically integrated firm's total per unit cost of production is the marginal cost of the input plus the marginal cost of producing the output. The unintegrated producer's total per unit production cost is the price of the intermediate good plus the marginal cost of producing the output. Notice that if the marginal cost of transforming inputs into outputs is the same for both firms, the difference in their per unit production cost is the opportunity cost of the input. Salinger models the situation as the integrated firm charging a markup over marginal cost to the unintegrated producer. Hence, the integrated firm has a cost advantage in production if there is a positive markup.

Salinger hypothesizes that vertically integrated firms will not sell or purchase inputs in the upstream market. The possible purchase of inputs in the upstream market has been mentioned in earlier vertical integration literature, notably Hamilton and Mqasqas (1997). A vertically integrated firm may wish to buy the input in order to limit

the availability to its downstream rivals. The reduced availability of the input would raise the price of the input to downstream firms, raising their costs.

The basis of Salinger's supposition relies on a series of assumptions. First of all, if the integrated producer sells one more unit of the input to competitors, all other upstream producers will not change their outputs, and the downstream producer will increase its output by one unit. Secondly, if the integrated producer buys one more unit of the input, one unintegrated upstream supplier will increase its output by one unit to compensate. This leaves the downstream market unchanged. Lastly, Salinger makes an assumption with respect to marginal costs and prices. Allowing MC_I to be the marginal cost of input production, MC_F to be the marginal cost of the final good, P_I to be the price of the input, and P_F to be the price of the final good, Salinger assumes that $MC_I < P_I < P_F - MC_F$.

If the integrated firm were to purchase inputs in the upstream market, total input supply remains unchanged by the second assumption above. Also, if the integrated firm buys inputs at a price which is higher than its marginal cost of producing the input (the first inequality in the third assumption), then the integrated firm is clearly not profit-maximizing. It should produce the input for itself and not purchase anything in the upstream market.

If the integrated firm is originally selling in the input market, suppose it decides to reduce its sales to zero and increase production of the downstream product by the same amount as the reduction in input supply. According to Salinger's first assumption, downstream producers will decrease their production by a total of the increase in production from the integrated firm. This means there is no net change in the total output of the final good, leaving output price unchanged. By the second inequality of the third assumption, the gain in profit from the integrated firm producing the final product (after reducing its input sales) outweighs the lost revenue from input sales. Hence, a profit-maximizing firm would not sell in the input market. Therefore, given all the above assumptions, the vertically integrated firm chooses not to participate in any form in the input market.

Although Salinger's reasoning follows simply enough, he seems to make many assumptions in order to achieve his desired outcome. With respect to the second

assumption, it seems rather strange that for the integrated firm to assume that if it increases its sales of the input, that all remaining input suppliers leave their production the same. The effect of the action falls upon the downstream producers. Salinger reinforces his assumptions however by claiming that the integrated firm makes a Cournot assumption concerning its actions on either the input market or the final good market, but not both. Therefore in line with Cournot competition, the firm makes its decision *taking the output of its rivals as constant*. Reaction stems from the market in which no Cournot assumption is made.

In determining the Cournot equilibrium at each stage of production, Salinger assumes a successive oligopoly. In other words, there is an upstream oligopoly and a downstream oligopoly. Final good demand is linear, and downstream output and downstream price are both functions of the input price.

With a vertical merger, the newly integrated firm does not participate in the input market for reasons described above. Hence, a supplier of the input is lost. This has the effect of increasing the price for the input to production. Ceteris paribus, this leads to a higher price for the final product. On the other hand, the merger eliminates the markup concerning the two merging firms (again, since the integrated firm does not participate in the input market). Therefore, final product price can seemingly increase or decrease upon the occurrence of a vertical merger, depending on which effect dominates.

Salinger finds that a vertical merger in a successive oligopoly model has two effects. The first is the aforementioned anticompetitive effect. A lower number of suppliers of the input to production will cause the production costs of the downstream producers to increase. The second effect is that the integrated firm produces more of the downstream product than the previously unintegrated downstream firm. As a result, the residual demand curve for the remaining unintegrated downstream firms will fall. Along with this decrease in demand will come a decrease in the demand for the input to production from upstream suppliers. This reduction in demand will cause the input price to fall.

As mentioned above, the OSS definition of foreclosure (among many others) is when there is an increase in the input price. Notice that in Salinger's model, the input price may actually *decrease* if the residual demand effect is greater than the reduced input

supply effect. This implies that vertical integration may not be anticompetitive (foreclosure inducing).

2.2.D. Vertical Integration and International Concerns:

Vertical integration is not a country-specific phenomenon. In other words, the activity of vertical integration in a nation may influence the behavior of dependent firms in another nation. Barbara Spencer and Ronald Jones (1992) present a model where a downstream firm in a home market is somewhat dependent on a vertically integrated firm in a foreign nation for input supply. Given this scenario, Spencer and Jones analyze responses of the foreign vertically integrated firm to various tariff and subsidy policies.

The motivation for their paper is the notion that some countries that have an abundance of raw materials, may restrict exports in an attempt to stimulate domestic production of a final product. If firms do indeed increase production, then exports to a foreign market may also increase. This nation uses strategic trade policy at the input (intermediate) stage in stimulating downstream domestic exports.

The model consists of two countries: home and foreign. In the home country, there exists a downstream firm that produces output using both its own and imported inputs (homogeneous, obtained at marginal cost regardless of origin) from the foreign nation. In the home country, the input is produced at a high marginal cost. In the foreign country, there is a firm that controls exports of both the input and the final product. The input is produced in the foreign country at a low marginal cost. The downstream firms play Cournot in the final output market in the home country. As a precondition to their model, Spencer and Jones assume an abundance of the input (natural resource) in the foreign country to ensure a constant marginal cost.

With respect to Cournot competition, the subgame perfect equilibrium is derived from a two-stage game. In the first stage, the vertically related firm or the upstream firm (which controls the exports of the input) determines the export strategy for the input. In Stage 2, firms play Cournot competition in the final product. Lastly, it is important to note that the home country commits on its strategic trade policy (tariff, subsidy on imported inputs, and subsidy to local production) at the beginning of the game. The game is solved using standard backward induction.

Spencer and Jones find that the foreign vertically integrated firm may restrict the availability of input supply to the higher cost domestic firm under Cournot competition. The integrated firm thus forecloses the domestic firm. A firm with a vertical relationship finds it beneficial to increase the input price above a monopoly level (i.e., that level which results when the upstream division controls exports of the input). Subjecting the home firm to this higher input price will cause a reduction in the home downstream output supply. This higher price benefits the integrated firm due to the higher output price it receives from its final product exports (provided of course that the home country tariff is not prohibitive). Thus, the vertical relationship is clearly anticompetitive to the home firm.

In considering home country trade policies, Spencer and Jones find that tariffs on downstream products will increase the input price in a situation of a foreign monopolist. A tariff on final goods results in an increased demand for inputs by the domestic firm. When outputs are assumed to be strategic substitutes, the foreign monopolist increases the input price in response to the increased demand.

In a previous work concerning vertical relationships and international trade policy, Spencer and Jones (1991) analyze the possibilities of a vertically integrated firm either exporting inputs to a higher cost rival, or foreclosing the rival. Spencer and Jones approach the decision as being controlled perhaps mainly by the government. In other words, government trade policy can influence the possible exporting of the input to production along with the final product.

The model considers two countries: Country 1 and Country 2. Firm 1 is located in Country 1, and exports a downstream product to Country 2. Firm 2 is located in Country 2, and this firm has the higher production costs. Thus Firm 1 is the lower cost vertically integrated firm. The firms are assumed to have differing production costs due to international differences in factor endowments and technologies. Firm 2 need not only import the upstream good, but has the option of additionally producing the upstream good on its own. Firm 1 is assumed to produce the intermediate good at a constant marginal cost, while if Firm 2 chooses to produce the input itself, does so at a higher and increasing marginal cost.

The subgame perfect equilibrium is found for both two-stage Cournot competition, as well as Bertrand price competition. In the first stage, Firm 1 sets the price of the input that it charges to its higher cost rival. Stage 2 entails downstream product Cournot (or Bertrand) competition. As a precondition to the game, Country 1 sets its trade policies. Specifically, the government sets a subsidy to its downstream exports and a tax on upstream exports. The subsidy and tax may be either positive or negative. Also prior to the game, Country 2 could possibly commit to a tariff on imports of the downstream product from Country 1.

The main question stemming from this model is obvious: Should Firm 2 be expressly concerned about being foreclosed from input supply given their competitive disadvantage with Firm 1 in input production? Obviously, Firm 1 will only supply the input to Firm 2 if a decrease in the input price (below that which would achieve foreclosure) increases Firm 1's total profit. For example, Spencer and Jones find that in a situation where a) it is not efficient for Firm 2 to produce the input, and b) there is a zero tariff rate on downstream products from Country 1, Firm 1 will foreclose Firm 2 (not export the input to production). Firm 1 then captures the downstream market as a monopoly. With no input to production, Firm 2 cannot enter the market. However, with a tariff on downstream products, Firm 1 does supply the input to Firm 2, allowing Firm 2 to produce. By engaging in upstream sales to Firm 2, this will help make up for lost profit from reduced downstream exports into Country 2. Other possibilities and alternative tariff/subsidy sizes are presented for both Cournot and Bertrand competition. The underlying conclusion is that the importing country (Country 2) can prevent input foreclosure (hence cause vertical supply) if it levies a somewhat high tariff on downstream imports from Country 1.

2.3. Other Types of Integration:

For completeness, it should be noted that there are two other types of integration beyond the two forms mentioned above. There is a second type of vertical integration which is called forward vertical integration, briefly mentioned in Lin's work above. This would entail a downstream firm merging with a distribution firm, or a wholesale firm merging with a retail firm. The motives for forward vertical integration are essentially the same as for backward. The only difference is where the two firms are with regards to

the production and/or the distribution process. The final type of integration comes in the form of conglomerate mergers. In this case, two firms which are not alike merge together. For example, if an automobile manufacturer merges with a cosmetics company, this would most likely be categorized as a conglomerate merger. The principle motive for this type of activity is diversification, or the act of reducing risk. With respect to the example, suppose that the owners of the automobile manufacturer are forecasting a rather significant downturn in the automobile industry. In response, they may wish to use idle assets to hedge against possible losses. The owners may decide to invest in a market which ideally will be on an upswing during the automobile market downturn. This may be a cosmetics or a computer firm. The owners of the automobile firm would not want to invest in any firm that is related to the automobile industry. It stands to reason that if the automobile industry is predicted to slow down, then related industries will likewise suffer, defeating the entire purpose of diversification.

2.4. Foreign Direct Investment and Trade Restrictions:

Integration, whether it is horizontal or vertical, is usually described as *foreign direct investment*, or FDI. Foreign direct investment has been approached from both theoretical and empirical points of view. Jagdish Bhagwati, Elias Dinopoulos, and Kar-Yiu Wong (1992) mention two different forms of FDI: quid pro quo and tariff-induced. Sometimes FDI is used by a firm to prevent a levying of tariffs or other trade restrictions. This is referred to as quid pro quo FDI. Specifically, if a firm wants to capture more of a foreign market, increasing exports to that market will likely increase protectionist pressure in that market. If the firm instead engages in FDI into that market, the protectionist threat can sometimes be neutralized. In other words, the FDI is tariff-defusing. This is different from tariff-induced FDI. In this case the tariff is already known. As a result, a firm engages in FDI to avoid the cost of the tariff. Bhagwati et al. (1992) cited a study by the Ministry of International Trade and Investment (MITI). This study found that Japanese firms engaging in FDI between 1980 and 1986 did so primarily to ease national tension regarding imports. This is most likely a type of tariff-defusing FDI to avoid trade restrictions.

2.4.A. Endogenous Protection and Foreign Direct Investment:

Tariff imposition by a nation's government typically does not materialize without angering some segment of an elected official's constituency. Ceteris paribus, trade impediments lower the number of goods coming into the imposing nation. This lower availability of competing goods drives the prices of those goods upward. While restricting imports (and hence competition) will please domestic producers, higher output prices will anger consumers. An elected official must weigh the benefits of tariff imposition against overall consumer welfare. The key question is why do elected officials risk angering a large constituency (consumers) while assisting a rather small one (producers)? The answer is twofold. First of all, producers are more organized than consumers. They can more easily lobby policymakers as a result. Secondly, producers are more likely to contribute large sums of money to an official's political action committee (PAC), or to the political party itself. These campaign contributions help an elected official run for reelection. While an elected policymaker most likely wishes welfare for his or her constituents, he or she is also concerned a great deal about personal welfare.

This problem is specifically modeled in a work done by Gene Grossman and Elhanan Helpman (1994). Their work deals with political contributions specifically influencing trade policy. In fact, the title of their paper is "Protection for Sale," which is essentially the problem being modeled.

The model used is a small, competitive economy that is a world price-taker. International trade textbooks pose that what is most efficient for this economy is a system of free trade. Grossman and Helpman posit that any deviation from free trade must result from political motives. A good is produced using only labor, and there exist n additional products which use labor and a sector-specific input. The owners of the sector-specific inputs make up different lobbies. The lobby groups will give political contributions to incumbents, who are of course responsible for setting current trade policy. Conceivably, the lobby groups will give money to those officials who most support their cause. But most importantly, money is given in an attempt to influence results favorable to the lobby group. Each lobby represents one of the sector-specific input owners. The incumbent's

objective function is to maximize a weighted sum of these political contributions and a measure of aggregate social welfare.

Since the world price is taken as given, the domestic price should equal the exogenous world price for a particular good. If the domestic price is greater than the world price, then the domestic country has imposed either a tariff on imports or a subsidy for exports. Conversely, if the domestic price is below the world price, then this implies either an import subsidy or an export tax. Lastly, it is assumed that the government redistributes this net revenue from tariffs and subsidies uniformly to the country's voters. The equilibrium is found from a two-stage noncooperative game. In the first stage, political lobbies simultaneously choose a contribution schedule. In the second stage, the government sets trade policy. With respect to the contribution schedule, lobbies make their bids knowing the government's objective function.

Grossman and Helpman find that protection is positively-correlated with the relative weight of political contributions with respect to voter welfare. Additionally, protection is negatively-correlated with the fraction of voters belonging to an organized lobby. Note the intuition of these two results. With respect to political contributions, elected officials will be more likely to pursue lobby-favored trade policy if that elected official weights these contributions more than voter welfare. Regarding the second result, if a greater and greater number of voters are represented by a lobby group, then political competition through campaign contributions results in less protection. As mentioned above, voters prefer free trade. But if voters are in competition with other lobby groups, the greater number of voters belonging to organized lobbies will contribute to cause the government to pursue free trade (hence a lower level of protection).

In a notable work by Kishore Gawande and Usree Bandyopadhyay (2000) (hereafter G-B), the protection for sale problem is put to an empirical test. G-B use data on U.S. nontariff barriers, and wish to compare the Grossman-Helpman model to previous empirical work on endogenous protection.

G-B specify three equations to be estimated (relating to the two stages mentioned in the theoretical description above): trade protection (measured by nontariff barriers), political contributions, and an import penetration ratio. In the first stage, the contribution vector is identified. Each lobby group provides the government with its contribution

schedule relating to possible trade policies. Secondly, the government's objective function is then maximized taking into account the equilibrium set of contribution schedules. Therefore, trade protection is endogenous, and depends on the level of contributions by lobbies. The coefficients are obtained by estimating the equations using the two-stage least-squares estimation procedure.

G-B test several hypotheses concerning protection and intermediate goods and protection and the degree of lobby competition. The first hypothesis is that the higher the protection on intermediate goods used in downstream production, the higher the protection granted to the downstream industry which relies on those inputs. The second hypothesis states that the greater is the degree of competition among lobbies (measured by the Herfindahl-Hirschman index), the greater is contribution spending by the lobby groups.

G-B find that the rate of protection on intermediate goods has a positive influence on the rate of protection of the downstream product. Additionally, they find that PAC (political action committee) spending does respond to deadweight losses stemming from protection. This means that the government, in its weighted objective function, wishes to compensate for the deadweight losses of levied protection. Additionally, G-B find that lobby competition does lead to greater lobby spending. Recall that lobbies make political contributions in connection with the strength of its rival. Each lobby wishes for its desired outcome to occur, hence it must make political contributions to the government that match up to its strong rivals.

Given these last two results, it appears that contributions in connection with lobby competition pale in comparison to contributions to compensate for the deadweight loss from protection. Hence the government obviously weights aggregate social welfare a great deal, and lobbyists have to contend accordingly. G-B conclude that lobbying does influence protection; protection is indeed sold by the government.

In March 2001, the United States Senate began open floor debate on campaign finance reform. Advocates of campaign finance reform wished to eliminate unlimited contributions to political parties, known as "soft money." If campaign finance reform were to eventually succeed, then the kind of influence presented here would be reduced, if not eliminated. It is, however, important to stress the main conclusion reached by

Grossman and Helpman: political contributions from a political lobby results in more favorable trade policies (protection) for the lobby group.

2.4.B. Protection-Building Trade and Foreign Direct Investment:

Keeping the above conclusion in mind is useful when discussing foreign direct investment and endogenous protection. FDI can be used strategically by a firm upon *increasing* exports and hence the level of protection imposed upon a firm and its competitors. For example, a firm may increase its exports to a targeted market, knowing that protection will be levied not only on itself but also on its competitors. Upon tariff imposition, a firm may then engage in FDI (tariff jump), opening a plant in the targeted market and establishing a presence there, whose output would be tariff-free. This would then leave the new multinational's competitors facing the tariff alone. This is a procedure known as *protection-building trade*. Of course other factors must be taken into account, such as the proposed multinational's fixed costs of opening a new plant relative to those of its competitors. After all, if one firm can do this, it stands to reason that its competitors could as well. Secondly, as mentioned above, the targeted market's society may view multinationals as outsiders and shun the business.

Bruce Blonigen and Yuka Ohno (1998) present a situation of strategic FDI in an oligopolistic environment. They introduce a two-period model, consisting of three countries, Home, Country A, and Country B. Firm A is located in country A, while Firm B is located in Country B. This duopoly competes for the Home market, where there is a competitive fringe. Blonigen and Ohno assume that firms face increasing marginal cost, regardless of production location. Firms A and B play a quantity-setting game in their competition for the Home market. The firms play a two-period, two-stage game. In Period 1 Stage 1, Firms A and B export to Home. In Period 1 Stage 2, a country-specific tariff is levied as a function of the exports in Period 1 Stage 1. This is endogenous protection in that the level of tariff depends upon export invasion. In Period 2 Stage 1, Firms A and B observe their levied protection, and decide whether or not either to engage in tariff-jumping FDI in Home at some fixed cost, or simply continue exporting. Lastly, in Period 2 Stage 2, the duopoly plays Cournot. The model is solved through backward induction.

The crux of Blonigen and Ohno's work lies in the concept of protection-building trade itself, and not so much on the results that occur from stage to stage in the Cournot game. Multiple equilibria can occur if the exporting firms (Firms A and B) have different fixed costs of FDI. One of these equilibria is the protection-building trade result.

In their paper, Blonigen and Ohno discuss studies which have shown that, regardless if the exporting (foreign) firms are from the same country or different countries, future protection is a response to not only one firm's own actions, but also on that of its rivals (Prusa (1997), Hansen and Prusa (1996)). Accordingly, if Firm A floods the Home market with exports, not only could Firm A face tariffs, but Firm B could as well. Blonigen and Ohno specifically model the tariff functions in this manner. They assume that a firm's future protection depends both on itself and its rival, although the firm's tariff rate is more sensitive to its own exports than those of its rival. Allowing "one" to denote first-period exports and τ to represent the tariff rate, mathematically, this assumption would be expressed as $\tau^i \equiv \tau^i(x_1{}^A, x_1{}^B)$; where: $\dfrac{\partial \tau^i}{\partial x_1{}^i} \geq \dfrac{\partial \tau^i}{\partial x_1{}^j} > 0$.

Herein lies the rationale for flooding the Home market with exports. Concerning protection-building trade, if Firm A has a lower fixed cost of FDI than Firm B, then Firm A can open a plant in Home and produce locally. Firm B will likely continue exporting in the presence of high costs of FDI. In competition for the Home market, Firm A would then have the advantage because of its tariff-jumping.

In deriving best-response functions, Blonigen and Ohno consider four cases: i) both firms engage in FDI, ii) Firm A invests but Firm B does not, iii) Firm A does not invest while Firm B does, and iv) neither firm invests. Quite obviously, if the costs of foreign investment are close to zero, then case i) will occur. Conversely, if the costs of FDI are large (perhaps prohibitively so), then case iv) will likely happen. Cases ii) and iii) will depend upon the relative costs of FDI. Thus, protection-building trade is one of the equilibria that can occur from these cases. If Firm A engages in protection-building trade because of its relatively low cost of FDI, Firm B, with the higher cost, will likely reduce first-period exports to Home because of a tariff threat in period 2.

Blonigen and Ohno's work is quite interesting, but not exactly new. The model they use is highly dependent upon the relative fixed costs of FDI. Protection-building

trade possibilities come from this required assumption. Tariff-jumping adds nothing new to the literature, and firms pursuing activities that provide the lowest marginal cost of supply is nothing more than rational economic behavior. Additionally, Bhagwati et al. (1992) claim that FDI may actually cause friction between nations, instead of goodwill through job creation. They offer the case of Japanese FDI in the United States as one example. Japanese FDI is seen as a threat to the U.S. and has caused a backlash. Lee Iacocca has before recommended to add Japanese FDI production to Japanese exports.[6] If exports plus Japanese FDI production exceeded Japan's VER limits, then Japan could be subject to duties. This could possibly cause governments to be wary in allowing foreign investment. However, the Blonigen-Ohno work is beneficial and adds to the literature in that protection-building trade is specifically modeled, and is only one possibility among others (both firms tariff-jump, and both firms react accordingly to endogenous protection by limiting exports with a tariff threat).

2.4.C. Competitiveness and Foreign Direct Investment:

As noted above, foreign direct investment could be pro-competitive when a new plant is opened, or it could be anti-competitive when considering mergers. When one firm invests in another firm in an oligopolistic setting, the interdependence of all the firms in the market environment will cause changes in behavior. For example, if Firm A merges with Firm B, the market is more concentrated. Any production or pricing decisions undertaken by the new Firm AB will affect the output and price decisions of Firm AB's competitors: Firm C, Firm D, and Firm E. Thus FDI is a method for one firm, in this case Firm A, to indirectly influence the decisions of its competitors. If Firm A is forward-looking, then it can anticipate what its rivals' actions will be, and act accordingly.

Suppose further that integration is vertical and not horizontal. Assume that Firm A merges with an input supplier, and now has a significant share of the input market. Thus Firm A can manipulate the input price that its rivals, Firms B, C, D, and E, will face. As noted above, if Firm A acts to increase the input price, then production costs of the downstream firms increase, and their combined production will fall. If Firm A can

[6] Jagdish Bhagwati, Elias Dinopoulos, and Kar-Yiu Wong, "Quid Pro Quo Foreign Investment," *AEA Papers and Proceedings*, May 1992, 82:2, 189.

avoid the higher input price it caused, it can then move to increase production and capture more market share and profit. This is a procedure that is sometimes referred to as "raising rivals' costs." As before, the motive is for one firm to act, then either directly or indirectly influence its competitors' actions.

Steven Salop and David Scheffman (1983) focus on anticompetitive behavior from this standpoint. This cost-raising behavior is still predatory, but not from the output price standpoint. Raising rivals' costs is a more subtle approach to predation. If a competitor's costs can be raised successfully, that competitor could be forced to leave the industry. Even if a competitor does not leave the industry, it is much simpler (and more profitable) for a firm to compete with a relatively high-cost competitor. Also, using predatory pricing to banish a competitor from the industry is based on uncertain future profits, while incurring assured short-term losses (or lower profits at the very least). Note that action such as this, despite its subtlety, would still be in violation of antitrust law. If firms engage in exclusive dealing to raise competitors' costs, this is in violation of Section 1 of the Sherman Act. If low-price upstream firms agree to boycott certain downstream firms at the behest of those firms' competitors, this is a concerted refusal to deal, and is also in violation of Section 1. Additionally, if firms collude to act in this manner, this could likely be categorized as conspiracy. Each one of these possibilities are instances of bilateral or multilateral action, and is in violation of Section 1. Lastly, Salop and Scheffman pose the possibility of this behavior being an attempt to monopolize an industry. If this is found to be true, this would violate Section 2 of the Sherman Act.

Salop and Scheffman (1987) model this behavior in terms of competition between a predator and a competitive fringe. A section of their paper that is particularly relevant to this dissertation deals with vertical integration. In this case, the predator is assumed to be somewhat vertically integrated. This means that the firm produces some of its overall input needs for itself, and purchases the remainder. The predator may decide to overpurchase the input, even if the input cost is more than the firm's own marginal cost of internal input production. With the predator overpurchasing the input, this decreases the supply of the input available to the fringe, raising their costs. The effect on the fringe (and the reduction in output that will follow) may be greater than the higher cost of the input to the predator on the open market.

This activity is similar to firm behavior observed in the former Soviet Union. Firms in the Soviet Union were subject to production quotas. Ministers were responsible for the attaining of these targets. Sometimes firms demanded more of the input than they needed, assuring themselves of future input supply necessary to achieve production quotas. This input supply overpurchase caused shortages for other firms using the same input. This led to large restrictions in output and hence goods shortages.[7] If prices would have been allowed to fluctuate freely, they would have risen to incredibly high levels. These higher prices would then act to discourage input overpurchase, hence eliminating the problem.

These actions by firms are not without scrutiny, however. Even if a merger is allowed to take place by the Federal Trade Commission and the Justice Department, any horizontal restraint to competition is usually deemed illegal *per se* by the Sherman Act. Similar to horizontal integration above, a horizontal restraint is any restraint of trade at the same level of production. For example, anticompetitive behavior between two competing clothing manufacturers would be horizontal. By contrast, vertical restraints to trade are restraints that occur in the same industry, but at different levels of production. An example would of course be OPEC's continuing oil production contractions. Oil is a significant input to production in items such as heating oil, diesel fuel, and gasoline. The OPEC oil cartel agrees to limit production of oil, hence raising its price on the world market. This makes energy bills and gasoline more expensive for firms and consumers. Since OPEC is not under U.S. antitrust jurisdiction, this behavior can go unchecked. However, the United States would not tolerate this behavior inside its borders, because it is a clear restraint of trade and a violation of antitrust legislation. In evaluating vertical restraints however, they are not necessarily deemed illegal *per se*, but are subject on a case-by-case basis to the rule of reason test under the Sherman Act. This approach is motivated by the sometimes conflicting profit maximization goals of suppliers and producers mentioned above. Increases in input prices may not necessarily be anticompetitive by the upstream firm, but may be due to demand shifts or some other valid economic reason.

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[7] Paul Gregory and Robert Stuart, *Russian and Soviet Economic Performance and Structure*, 7th ed., (Addison Wesley Longman, 2001), 117.

In the United States, explicit collusion is most certainly illegal, and easily identified if an anticompetitive agreement exists in writing. Although implicit, or tacit, collusion is also against U.S. law, it is not simple to prove. The most common form of tacit collusion is price leadership. Put simply, price leadership is the act of one firm (considered an industry leader) setting a price for output, which signals its competitors to follow likewise and increase their prices in the very near future. The firms are acting collusively, but there is no written agreement for them to do so. It is an "understanding."

Despite its difficulty to prove, price leadership and price fixing are vigorously investigated by the government. Perhaps one of the most famous standoffs between the government and industry was in 1962 with President John F. Kennedy's statement on the steel crisis. United States Steel increased the price of steel by six dollars a ton, drawing harsh criticism by President Kennedy:

> Simultaneous and identical actions of United States Steel and other leading steel corporations increasing steel prices by some $6 a ton constitute a wholly unjustifiable and irresponsible defiance of the public interest....
>
> If this rise in the cost of steel is imitated by the rest of the industry, instead of rescinded, it would increase the cost of homes, autos, appliances, and most other items for every American family.[8]

Despite this and countless other investigations of price fixing, it doubtlessly continues in the United States regardless of antitrust legislation. It is very difficult for the government to show that price increases by themselves are anticompetitive. The price leader's defense for the initial price increase will most certainly be claiming a response to changing economic conditions. Since other firms follow the leader, when they increase prices they can claim the same defense. After all, if the price leader is responding to "changing economic conditions," then it stands to reason that other firms in the same industry would have to respond to those same conditions. With changing economic conditions coming in a multitude of possible forms, the government's case of price leadership is often difficult to prove.

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[8]John F. Kennedy, "Statement on the Steel Crisis—April 11, 1962," 6 June 1996, <http://www.cs.umb.edu/ jfklibrary/ j041162.htm>, (16 March 2002).

The point of all this is that even though firms have three ways of increasing their presence into other markets (exports, FDI greenfield, and FDI mergers), their actions upon successful integration may or may not avoid any antitrust jurisdiction. It again depends on whether the action is horizontal or vertical in nature.

2.5. Introduction to the Theoretical Chapters:

This dissertation seeks to expand on the aforementioned literature regarding horizontal integration and asset ownership, optimal foreign asset ownership, and vertical integration and price leadership.

2.5.A. Description of Chapter Three:

The third chapter studies the effects of increased foreign asset ownership on the pattern of trade, volume of trade, and firm profit. The model modifies the Brander-Krugman reciprocal dumping framework to include a degree of ownership in the profit equation of the domestic (acquiring) firm. The higher the level of ownership, the greater fraction of foreign firm profit that accrues to the domestic firm. If the ownership level reaches a certain point, then the domestic firm attains managerial control of its foreign competitor.

The third chapter shows the effects of increased asset ownership on each of the aforementioned microeconomic variables under both degrees of ownership, which I name "non-controlling" and "majority" settings. I find that in a non-controlling interest setting (ownership with no explicit control by the domestic firm), the domestic firm sells less in both the home and export market, the foreign firm sells more, the volume of trade falls, and the foreign firm sees increased profit. The total profit of the domestic firm is ambiguous given the makeup of the domestic profit function. On the one hand, it is sacrificing market share in favor of the foreign firm. On the other hand, anything that benefits the foreign firm in turn benefits the domestic firm. Thus, the ultimate effect (mathematically) on domestic firm profit is ambiguous.

In a majority ownership setting (ownership with explicit control by the domestic firm), it is the domestic firm which sells more in both markets, while the foreign firm sells less. Additionally, the volume of trade again falls, and the foreign firm observes lower profit from the reduced market share. The domestic firm has essentially become a multiplant monopoly, with the foreign firm becoming basically a subsidiary of the

domestic firm. This movement toward a monopoly position should provide the domestic firm with increased profits above any prior symmetric duopoly position. In both ownership settings, total output availability falls in both nations, increasing output price in both countries.

The results from this chapter are interesting and somewhat counterintuitive at first blush. The Brander-Krugman reciprocal dumping model is driven by firm symmetry and transportation costs. It is the presence of positive transportation costs that drives the reciprocal dumping result. I find that the domestic firm will actually increase its level of exports to the foreign country upon achieving managerial control, despite the presence of transportation costs. This appears to be paradoxical in that transportation costs are a waste of resources if the domestic firm has the capability of producing locally, as it will when it achieves managerial control of the foreign firm. The fourth chapter describes why this result is not necessarily paradoxical.

2.5.B. Description of Chapter Four:

The fourth chapter of this dissertation builds upon work done in the third chapter. Comparative statics results from the third chapter are used in deriving the results for the fourth chapter. The motive of the fourth chapter is to find the optimal level of ownership that the domestic acquiring firm would pursue. In other words, is the optimal level of ownership that in which a non-controlling interest or majority ownership is achieved? A two-stage Cournot game is assumed. In the first stage, the optimal level of ownership in the foreign firm is attained. In the second stage, the firms play Cournot. In finding the optimal level of ownership, Kuhn-Tucker programming is used. Using backward induction to find the subgame perfect Nash equilibrium, it is found that the optimal level of ownership is that in which the domestic firm acquires managerial control. This is due to the fact that in the non-controlling interest ownership setting, the firm's total profit was ambiguous due to the makeup of the domestic profit function (as described above). In the majority ownership setting, the domestic firm can exercise managerial control. It is this managerial control that allows the domestic firm to enjoy profits which exceed the initial symmetric duopoly profits.

2.5.C. Description of Chapter Five:

The fifth chapter of this dissertation deals with backward vertical integration, the concepts and reasons of which were discussed above. The chapter presents a successive oligopoly, in that there are two upstream firms located in a home market, each of which produce a homogeneous input. Additionally, three downstream firms are assumed. One of these firms is located in the home market, while the other two are each located in a respective foreign country. These downstream firms compete for the home market. Protection-building trade is a precondition to the model. In other words, one of the foreign downstream firms will increase its level of exports to the home country in an attempt to have tariffs imposed upon both itself and its foreign rival. The invading firm thus tariff-jumps into the home market by not pursuing greenfield investment, but by acquiring one of the upstream firms.

The chapter illustrates a four-stage Cournot competition model. It is solved through backward induction to find the subgame perfect Nash equilibrium that results. The game follows that presented by OSS. In Stage 1, the invading foreign downstream firm vertically merges with one of the upstream suppliers in the home market. In Stage 2, this new vertically integrated firm makes a decision with respect to the input price. It can decide either i) not to supply the input to its downstream competitors, or ii) to supply the input to competitors, but act as leader in the input pricing stage. This is not an uncommon assumption. Larger (or dominant) firms in an industry are sometimes looked to for leadership with respect to prices. It is common behavior for one firm to increase price, while other firms follow suit soon thereafter. Also, this leader-follower behavior can be explained with respect to conclusions reached by Dowrick (1986). Given downward sloping reaction functions, if one firm takes the lead, the other firm prefers to follow. This holds true as long as the firms are not symmetric.

The equilibrium shows that the foreign downstream firm which engaged in protection-building trade does not "raise rivals' costs" as in the traditional sense. In fact, the vertically integrated firm through its price leadership forces all downstream firms to a collusive equilibrium. Thus, the integrated firm not only forecloses its rivals from the downstream product market in the home country, it forecloses *itself* as well.

The tariff imposition that the invading firm brought upon itself and its foreign downstream rival causes their exports to the home country to fall. Upon this tariff imposition, the downstream firm in the home market would wish to increase domestic production (given higher prices resulting from tariffs). This firm is prevented from gaining a stronger hold on its own market by the input price leadership assumed by the vertically integrated firm. Upon price leadership, the input price rises above the marginal cost of production. Thus, the domestic downstream firm is prevented from capturing more of its own market. The farsighted activity of the integrated firm causes all downstream firms (including the firm located in the home market) to move toward a collusive equilibrium, despite the absence of any collusion (tacit or otherwise) among the downstream competitors. These results hold provided the home downstream firm does not integrate with the remaining unintegrated upstream supplier. As long as the integrated firm supplies the input to competitors and assumes price leadership upon doing so, counterintegration by the domestic downstream firm is forestalled.

2.6. Concluding Comments:

The purpose of this chapter has been to introduce the relevant literature, which is the foundation for the following chapters regarding international trade theory and integration. A thorough review of reciprocal dumping, multinational corporations, vertical integration, and price leadership serves to provide an understanding of the motivation of the trade theory essays included in this dissertation. The goal is to find a place in the literature in which the material included in this dissertation will be viewed in the proper context. The chapters that follow begin the analysis of topics in applied microeconomics. Chapters Three, Four, and Five detail a study of integration issues in international trade. Chapter Six is an analysis of cost theory using a Bayesian approach. Each chapter will provide another (although brief) glimpse into the relevant literature for that essay. Each of the essays also presents an economic model for analysis, manipulations and/or extensions of the model, and concluding remarks.

CHAPTER THREE

INTRA-INDUSTRY TRADE AND HORIZONTAL INTEGRATION

3.1. Introduction:

In June 1996, the Ford Motor Company increased its stake in Mazda to 33.4 percent and assumed managerial control of the troubled Japanese carmaker.[9] With respect to recent international acquisitions and mergers, this was one of the more notable in an industry that has seen many ownership changes in the past decade. The Chrysler Corporation merged with the German Daimler Benz in 1998, resulting in one of the world's largest automobile manufacturers. The Ford Motor Company, as part of its ongoing effort to expand globally, has also acquired the Swedish Volvo. This type of horizontal integration is continuing to be seen more and more in other industries such as telecommunication and banking. In fact, the last few years have proven to be a period of immense merger growth. Specifically, the third quarter of 1998 was the first one that registered over $300 billion worth of mergers and acquisitions.[10]

This chapter shows that, even in the presence of transportation costs, a firm that acquires another and assumes control will in fact export *more* to that nation than before. In this modified model of reciprocal dumping, a counterintuitive result yields the exact opposite of the traditional definition of a multinational corporation. The domestic firm chooses paradoxically not to avoid transportation costs, but instead does the opposite. It floods the foreign market with exports, which consequently are dumped into that market. Prior to this result, it is shown that increased ownership in a minority sense will lead the acquiring firm to reduce its output in favor of the firm it has acquired.

This chapter presents a world duopoly framework, in which both firms are producing and exporting identical products. Previous notions concerning this type of *cross hauling* were mainly statements explaining that intra-industry trade comes about because of slightly differentiated products, a major characteristic of monopolistically-competitive markets. Given that consumers enjoy variety, it is obvious that two-way trade in not-quite identical products may evolve. Brander (1981) first discussed the

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[9] Updike and Naughton, 108.

[10] Securities Data Publishing, Inc., "Barreling Toward a $1 Trillion Year (Mergers and Acquisitions Statistics for 3rd Quarter 1998)," Jan.-Feb. 1999, <http://www.findarticles.com/m6402/4_33/53870401/p1/article.jhtml>, (16 March 2002).

concept of intra-industry trade in identical commodities when firms play Cournot in each output market. This separation from prior beliefs opened a new avenue of international trade theory. Specifically, Brander and Krugman (1983) revisit the notion of firm rivalry, and how country symmetry, basic profit maximization of two separated markets (domestic and foreign), and transportation costs lead to a dumping of output by both firms into each other's markets--reciprocal dumping. Weinstein (1992) extends the work of Brander and Krugman to show that this type of intra-industry trade in the presence of transportation costs and multiple firms cannot occur without dumping. Weinstein extends the literature further in stating that firms in competitive markets will have a greater tendency to dump exports unilaterally. Firms in markets that are less competitive will not find it as profitable to dump goods to competitive foreign markets. This is due to the lower price that results in more competitive markets.

Dei (1990) introduces the concept of multinational corporations (MNCs) in the reciprocal dumping model. Dei defines an MNC as a firm with headquarters in its home country, and then one or more firms in another country. The firms located abroad are actually plants that incur variable production costs. Notice then that this is an alternative to exporting to that nation. In other words, foreign investment instead of exporting is a second possible strategy. Dei concluded that it was more profitable for the headquarter firm in each nation to coordinate production locally (meaning through the plant located in the other nation), hence avoiding transportation costs. In other words, the use of the reciprocal dumping model leads to MNCs arising in each country.

With respect to international asset ownership, this essay refers to conclusions reached by Farrell and Shapiro (1990), and shows a robustness of their results in a non-controlling interest setting using this chapter's variation of the Brander-Krugman reciprocal dumping model. Majority ownership is then discussed, and the counterintuitive results that follow are investigated.

Concerning the non-controlling interest situation, Farrell and Shapiro show that, upon a firm increasing an ownership stake into another firm (but having no explicit control), the investing firm would lower its output in favor of all other existing firms. The change in profits to shareholders of the investing firm is ambiguous. They hypothesize that in a managerial control setting, increasing asset ownership would only

be profitable if some larger firm gains control of a smaller firm. The smaller firm would then reduce its output to augment the profit of the larger firm. Using the modified reciprocal dumping model, it is seen that firm profitability can result under managerial control without any preconceptions of firm size.

Section 3.2 provides the basic model setup, while Sections 3.3 and 3.4 detail the effects on exports with changes in international asset ownership, given that the acquiring firm has only partial ownership but no control. Section 3.5 presents an analysis of changes in exports of the two firms when the acquiring firm obtains enough ownership to exercise managerial control over the other. Section 3.6 discusses the effects on profits of both firms, while Section 3.7 provides concluding remarks.

3.2. Basic Model Setup:

Assume there exist only two firms in the world. In this duopoly, one firm is located in a domestic nation, while the other is located in a foreign country. Suppose the acquiring (or investing) firm is located in the domestic nation, while the other firm is located abroad. It is assumed that the two firms are each producing identical products at a constant marginal cost so that the markets may be separated. These two firms are initially equal in every way, with the exception that the domestic firm will eventually begin to take an interest in the foreign firm. The profit functions in this model are generally expressed as:

$$\pi^D = \pi^O + \beta\pi^F$$

and

$$\pi^F$$

where: D denotes the Domestic (acquiring) firm's total profit function

O denotes the acquiring firm's Own internal profit

F denotes the Foreign firm's profit function.

Notice the presence of β in the profit function for the acquiring firm. As this firm obtains increasing ownership of the foreign firm, this β term increases, taking a value in the interval [0,1]. A value of β equal to zero implies that the acquiring firm has no ownership in the foreign firm, while a value of one denotes absolute ownership. There exists a value in this interval where the acquiring firm has managerial control of the

foreign firm, and can dictate decision-making. The β term can be thought of as a degree of ownership variable.

For the domestic firm then, the first term of the profit function is the own internal profit of that firm's operations. In other words, this is the profit that occurs without domestic investment. The second term is the fraction of the foreign firm's profit that accrues to the acquiring firm, given the existence of some positive level of investment. Allow the total output available in the domestic nation to be denoted by X, and it is the sum of the domestically produced output for domestic consumption (x) and the exports from the foreign firm (y). Similarly, X^* is the total output available in the foreign nation, with x^* being domestic exports and y^* being foreign-produced output for foreign consumption. $P(X)$ is the domestic price, while $P^*(X^*)$ is the foreign price. Allow t to be the per unit transportation cost of exporting. As is standard in reciprocal dumping literature, assume that marginal costs, denoted c, are constant and identical for both firms. By doing this, the domestic/foreign market and its export market can be separated.

Specifically, the profit functions of each of the firms are as follows:

$$\pi^D = p(X)x + p^*(X^*)x^* - cx - cx^* - tx^* + \beta[p^*(X^*)y^* + p(X)y - cy^* - cy - ty]$$

and

$$\pi^F = p^*(X^*)y^* + p(X)y - cy^* - cy - ty$$

where: $X = x + y$

$X^* = x^* + y^*$.

The reader will notice that the cost of investment does not appear in the profit function of the domestic firm. The interest is to show what happens to the output levels and profits of both firms when the investing firm buys a portion of the foreign firm's assets. Given this, the investment cost of beta is sunk, and is simply a transfer of surplus from one firm to another of a given amount. Hence, costs of investment do not appear in the first-order conditions. This is not an unrealistic assumption. Many foreign direct investment papers

(FDI) present the cost of investment as some fixed cost. This is because FDI costs tend not to vary with output.

3.3. Foreign Exports and Domestic Production (Non-controlling Interest):

The objective is to perform an analysis of the trade patterns developing between the domestic and foreign markets in the wake of increasing domestic ownership of the foreign firm by the domestic firm. In this section, ownership is pursued in the context of the domestic firm acquiring shares of the foreign firm, but not enough to establish managerial control of that firm. In Section 3.5, the ownership situation in a setting of managerial control is presented.

In the non-controlling interest setting, to observe the effects on foreign exports, the first-order conditions of the specific profit functions above must be differentiated with respect to x for the acquiring firm and with respect to the exports of the foreign firm, respectively:

$$(1) \qquad \frac{\partial \pi^D}{\partial x} = p'(X)x + p(X) - c + \beta p'(X)y = 0,$$

$$(2) \qquad \frac{\partial \pi^F}{\partial y} = p'(X)y + p(X) - c - t = 0.$$

Total differentiation leads to:

$$\begin{bmatrix} A & C \\ D & E \end{bmatrix} \begin{bmatrix} dx \\ dy \end{bmatrix} = \begin{bmatrix} 1 & -p'(X)y & 0 \\ 1 & 0 & 1 \end{bmatrix} \begin{bmatrix} dc \\ d\beta \\ dt \end{bmatrix}$$

where:

$$\text{A} = p''(X)x + 2p'(X) + \beta p''(X)y < 0$$

$$\text{C} = p''(X)x + p'(X) + \beta p'(X) + \beta p''(X)y < 0$$

$$\text{D} = p''(X)y + p'(X) < 0$$

$$\text{E} = p''(X)y + 2p'(X) < 0.$$

The demand functions have the usual property of negative slope. Additionally, allow the demand functions to be concave. In other words, $p''(X) < 0$. In so doing, unnecessary ambiguity is alleviated. With this condition, A, C, D, and E are all negatively signed, which leads to the Jacobian determinant being positively signed.

Looking at domestic production for domestic consumption:

$$\frac{\partial x}{\partial \beta} = \frac{-Ep'(X)y}{|J|} < 0.$$

Intuitively, as domestic ownership of the foreign firm increases, domestic output will fall. This result is analogous to that which was stated by Farrell and Shapiro. The domestic firm will lower its production in order to augment the profits of the foreign firm, and realize positive returns from its acquisition.

Looking at the effects on foreign exports to the domestic nation:

$$\frac{\partial y}{\partial \beta} = \frac{Dp'(X)y}{|J|} > 0.$$

As domestic ownership of the foreign firm increases, exports from the foreign firm also increase. This result is not surprising. With a non-controlling interest, the foreign firm is still independent of the acquiring firm with respect to decision-making. The foreign firm will increase its export production, and will therefore increase its market share in the domestic nation, given that the acquiring firm has reduced its production. The domestic firm benefits, given the makeup of its profit function, even though it is the foreign firm that is increasing its presence in the domestic nation. Whether the domestic firm benefits in the aggregate depends on the magnitude of the positive effect on domestic profit from the investment into the foreign firm, relative to the negative effect on internal domestic profit as a result of reduced production. This matter is revisited in Section 3.6.

These findings lead to the first proposition:

Proposition 3.1: As the acquiring firm obtains partial ownership (but no control) of the foreign firm, exports from the foreign firm will rise, while domestic production for domestic consumption falls.

As for the total output available in the domestic market, since $X = x + y$, differentiate with respect to β:

$$\frac{\partial X}{\partial \beta} = \frac{p'(X)y[D-E]}{|J|} < 0.$$

As domestic investment increases, the level of total domestic output available falls. This must mean that domestic production falls at a greater level than foreign exports rise with a given increase in β, ceteris paribus. Before the domestic firm had acquired any

ownership of the foreign firm, the two firms were independent and acted as a world duopoly. When the acquiring firm increases its asset ownership, it appears to be moving more toward a monopoly position. Notice that the characteristics of a monopoly begin to arise: lower output availability and rising prices as a result.

3.4. Domestic Exports and Foreign Production (Non-controlling Interest):

In this section, a new system similar to the first must be constructed. Going back to the specific profit functions from Section 3.2, the first-order conditions are obtained by differentiating with respect to domestic exports (x^*), and foreign production for foreign consumption (y^*):

$$\text{(3)} \qquad \frac{\partial \pi^D}{\partial x^*} = p^*{}'(X^*)x^* + p^*(X^*) - c - t + \beta p^*{}'(X^*)y^* = 0,$$

$$\text{(4)} \qquad \frac{\partial \pi^F}{\partial y^*} = p^*{}'(X^*)y^* + p^*(X^*) - c = 0.$$

Allow the system to be expressed as:

$$\begin{bmatrix} A & C \\ D & E \end{bmatrix} \begin{bmatrix} dx^* \\ dy^* \end{bmatrix} = \begin{bmatrix} 1 & -p^*{}'(X^*)y^* & 1 \\ 1 & 0 & 0 \end{bmatrix} \begin{bmatrix} dc \\ d\beta \\ dt \end{bmatrix}.$$

The elements of the Jacobian are defined exactly as before, with the exception that asterisks are attached to the price and output variables, denoting foreign terms. Knowing this, the Jacobian determinant is signed positively. Evaluating the effect on domestic exports:

$$\frac{\partial x^*}{\partial \beta} = \frac{-Ep^*{}'(X^*)y^*}{|J|} < 0.$$

As domestic ownership of the foreign firm increases, exports from the domestic nation will fall. As the acquiring firm reduces its volume of exports to the foreign nation, it is giving way to increased presence in the foreign market by the foreign firm. With respect to foreign production for indigenous consumption:

$$\frac{\partial y^*}{\partial \beta} = \frac{Dp^*{}'(X^*)y^*}{|J|} > 0.$$

As the acquiring firm increases its ownership of the foreign firm, foreign production increases. Given that exports to the foreign nation have fallen, the foreign firm increases

its production to partially cover for this absence of output in the foreign market. If one infers increased firm profit from increased market share, profits of the foreign firm will unambiguously increase, which is shown in Section 3.6.

Formally stating the second proposition:

Proposition 3.2: As the acquiring firm obtains increasing ownership (but no control) of the foreign firm, exports from the domestic firm will fall, while foreign production for foreign consumption increases.

Notice then that the results reported by Farrell and Shapiro (1990) do continue to hold when using the Brander-Krugman duopoly model of intra-industry trade, suggesting a robustness of those results.

Observing the total output availability in the foreign nation, since $X^* = x^* + y^*$, again differentiate with respect to β:

$$\frac{\partial X^*}{\partial \beta} = \frac{p^{*}{}'(X^*)y^*[D-E]}{|J|} < 0.$$

Intuitively, increasing investment by the domestic firm is negatively related to total foreign output availability. This reduction in output will raise prices in the foreign market.

After seeing these results, it is interesting to note the changes in the total volume of trade that take place upon given increases in asset acquisition by the domestic firm. With a non-controlling interest, exports from abroad increase while exports from the domestic nation fall. Quite obviously, since x^* is falling in β while y is increasing, net exports are falling in the domestic nation and rising in the foreign nation. To determine the net change in the volume of trade however, take the absolute value of the difference in exports of the two nations. Since X and X^* both fall with increasing ownership, the change in y is less than the change in x^*. Thus, x^* falls by more than y increases, meaning that the volume of trade falls.

3.5. Total Production of Both Firms (Managerial Control):

When the acquiring firm continues to invest in the foreign firm, it was mentioned that managerial control is obtained by the domestic firm at a certain level of β (not necessarily one-half, but a value in which the domestic firm is the majority shareholder).

Upon this occurring, the duopoly gives way to a world multi-plant monopoly, with the acquiring domestic firm acting as the only independent seller. The foreign firm simply becomes a subsidiary of the domestic firm. A caveat should be introduced here. It is assumed that there exists no impediment toward a firm attempting to move toward a monopoly position. In other words, the governments of both nations do not block any attempts of foreign investment. The robustness of the Farrell and Shapiro results given a non-controlling interest has been seen. The interest is now to investigate the same variables with the assumption of managerial control. Given that the domestic firm is the investor, and is the sole decision-maker, its profit function is the only one of interest. In other words, that profit function is now maximized with respect to each output variable in consideration (x, x^*, y, y^*).

Differentiating the acquiring firm's profit function from Section 3.2 with respect to domestically-produced output for domestic consumption:

$$(5) \qquad \frac{\partial \pi^D}{\partial x} = p'(X)x + p(X) - c + \beta p'(X)y = 0\,.$$

Now differentiating with respect to foreign exports:

$$(6) \qquad \frac{\partial \pi^D}{\partial y} = p'(X)x + \beta p'(X)y + \beta[p(X) - c - t] = 0\,.$$

These first-order conditions lead to the following system:

$$\begin{bmatrix} K & L \\ M & N \end{bmatrix} \begin{bmatrix} dx \\ dy \end{bmatrix} = \begin{bmatrix} 1 & -p'(X)y & 0 \\ \beta & Q & \beta \end{bmatrix} \begin{bmatrix} dc \\ d\beta \\ dt \end{bmatrix}$$

where:

$$\mathrm{K} = p''(X)x + 2p'(X) + \beta p''(X)y < 0$$

$$\mathrm{L} = p''(X)x + p'(X) + \beta p''(X)y + \beta p'(X) < 0$$

$$\mathrm{M} = p''(X)x + p'(X) + \beta p''(X)y + \beta p'(X) < 0$$

$$\mathrm{N} = p''(X)x + 2\beta p'(X) + \beta p''(X)y < 0$$

$$\mathrm{Q} = -p'(X)y - p(X) + c + t\,.$$

It is necessary to keep the same conditions as before: that the demand functions are negatively sloped and concave. This allows K, L, M, and N to be unambiguously signed. No assumptions can be made regarding Q however.

With respect to signing the Jacobian determinant of this system, it is negative at all values of β except when $\beta = 1$. The Jacobian determinant in this case is $|J| = (p'(X))^2[\beta(2-\beta)-1]$. Notice that at a value of β equal to one, the Jacobian determinant would be zero, leading to undefined comparative statics results. Hence in the case of managerial control, $\beta \in [0,1)$. Therefore in evaluating comparative statics results, it can only be said that β can be in the neighborhood of one.

Looking at the change in domestically-produced output for indigenous consumption given a change in ownership, ceteris paribus:

$$\frac{\partial x}{\partial \beta} = \frac{-[Np'(X)y + QL]}{|J|} > 0 .$$

Assume that the transportation cost is not prohibitive; therefore, exports will be positive, and $p(X) > c + t$, allowing us to sign the comparative static result above as being positive (provided that $\beta \neq 1$). As the acquiring firm (already having managerial control) continues to increase its interest in the foreign firm (in order to capture a larger fraction of the profit of that firm), the output produced by the acquiring firm increases.

With respect to exports of the foreign firm:

$$\frac{\partial y}{\partial \beta} = \frac{KQ + p'(X)yM}{|J|} < 0 .$$

Given that the transportation cost is not prohibitive, the result can be signed negatively (provided that $(p'(X))^2$ is not sufficiently large), implying that exports from the foreign firm will fall with increasing β.

Before continuing, it is necessary to consider exports of the acquiring firm and foreign-produced output for foreign consumption. To do this, a new system must again be constructed. The profit function of the acquiring firm is differentiated with respect to x^* and y^*, and a new matrix results. As in the previous section, the elements of the Jacobian will be defined in the same manner, with the exception that asterisks are included on the output and price variables. Given this fact, the changes in x^* and y^* will

be analogous to the changes in x and y above: with increasing β, exports of the acquiring firm will increase, while foreign-produced output for foreign consumption will fall. Therefore, observe that the total production of the acquiring firm increases, while that of the foreign firm falls--the direct opposite of what was presented earlier with the non-controlling interest setting.

Formally presenting Proposition 3.3:

Proposition 3.3: Upon the acquiring firm gaining managerial control of the foreign firm (and continuing to increase its interest), the total production of the acquiring firm will increase, while that of the foreign firm will fall.

Notice the odd results derived in this section. Recall that the acquiring firm in the home market incurs a transportation cost in exporting abroad. The home firm upon further acquisition of the foreign firm directs the foreign firm to *decrease* production. This is rather unusual, given that the domestic firm could increase production of the foreign firm and hence avoid transportation costs. This is not the case here in this version of the reciprocal dumping model. The consequence of assuming homogeneous products and the presence of transportation costs are what drive these results, because these characteristics yield reciprocal dumping as long as each firm sells in the other's market.

With positive transportation costs, Brander and Krugman found that marginal revenue was higher in the export market, given that each firm in equilibrium has a smaller market share of the export market than of its own market. This follows from the fact that both firms were initially symmetric. Since marginal revenue is higher in the export market, each firm imposes a smaller markup over cost in its export market than in its own country. This is true because there is a higher elasticity in the export market than in the firms' indigenous market. Therefore, the export price (price for x^* if discussing the domestic firm) will be less than the foreign price (price for y^*). Thus the domestic firm consequently dumps exports into the foreign market. In other words:

$$p^*(X^*) - c - t < p^*(X^*) - c .$$

Given than marginal costs are identical for both firms, the reciprocal dumping result simplifies to:

$$p^*(X^*) - t < p^*(X^*) .$$

This is the simplified conclusion of Brander and Krugman's reciprocal dumping model. Given a lower net export price for domestic exports (which is the transportation cost wedge), the domestic acquiring firm will indeed *not* become a multinational. Dei's work involved the opening of a new plant, and not necessarily the purchase of an existing plant (i.e., a competitor) when firms decide to become multinationals. Additionally, if a firm wants to sell more output, the increase in production will lower the price in that market due to higher output availability. With trade, a firm can sell more in its export market, which will lower the foreign price to the detriment of the foreign firm. Thus the firm wishing to sell more can do so without adversely affecting the market in which it enjoys the largest market share. This is standard third-degree price discrimination, or in this case, dumping.

In deriving the domestic export and foreign demand elasticities for comparison, recall that in a situation of managerial control, the acquiring firm's profit function is of primary interest. If discussing the foreign market, then it is necessary to differentiate the domestic profit function with respect to both x^* and y^* to derive the elasticities. Allow (7) and (8) to be the following first-order conditions:

$$\text{(7)} \qquad \frac{\partial \pi^D}{\partial x^*} = p^{*\prime}(X^*)x^* + p^*(X^*) - c - t + \beta p^{*\prime}(X^*)y^* = 0,$$

$$\text{(8)} \qquad \frac{\partial \pi^D}{\partial y^*} = p^{*\prime}(X^*)x^* + \beta p^*(X^*) - \beta c + \beta p^{*\prime}(X^*)y^* = 0.$$

Rearranging (7), and allowing $\dfrac{p^*(X^*)}{\varepsilon_{x^*}} = -p^{*\prime}(X^*)x^*$, notice that:

$$\varepsilon_{x^*} = \frac{p^*(X^*)}{p^*(X^*) - c - t + \beta p^{*\prime}(X^*)y^*},$$

where ε_{x^*} is the price elasticity of demand of domestic exports from the home country.

For comparison, rearrange (8), and allow $\dfrac{p^*(X^*)}{\varepsilon_{y^*}} = -p^{*\prime}(X^*)y^*$, and accordingly find that:

$$\varepsilon_{y^*} = \frac{\beta p^*(X^*)}{\beta(p^*(X^*) - c) + p^{*\prime}(X^*)x^*},$$

where ε_{y^*} is the price elasticity of demand of foreign output for foreign consumption. Notice that these two elasticities cannot be compared in absolute. With respect to the numerators, the numerator for the domestic exports is larger than for foreign output, given that β is a term that is less than one. Additionally, in the denominator, it can reasonably be assumed that $\beta p^{*}{}'(X^*)y^* < p^{*}{}'(X^*)x^*$, since β is less than one, and y^* falls as x^* rises with increasing ownership in a majority setting. This allows us to make the assumption of the strict inequality.[11] Thus so far, $\varepsilon_{y^*} < \varepsilon_{x^*}$. This leaves the final terms in the denominator, which cannot be directly compared. $(p^*(X^*) - c - t)$ is in the denominator of ε_{x^*}, and $\beta(p^*(X^*) - c)$ is in the denominator of ε_{y^*}. The presence of transportation costs in the domestic export elasticity is the key difference between these two expressions. If β were arbitrarily close to one, the expressions would differ only by the magnitude of the transportation costs. But if a particular value to β is not assigned, the above terms cannot be directly compared. Therefore, the following inequalities and relationships are posed in three cases:

i) if $(p^*(X^*) - c - t) > \beta(p^*(X^*) - c)$, then ε_{y^*} is greater than, equal to, or less than ε_{x^*},

ii) if $(p^*(X^*) - c - t) = \beta(p^*(X^*) - c)$, then $\varepsilon_{y^*} < \varepsilon_{x^*}$, and

iii) if $(p^*(X^*) - c - t) < \beta(p^*(X^*) - c)$, then $\varepsilon_{y^*} < \varepsilon_{x^*}$.

In looking at the three different possibilities, consider *i*) first, as this is a rather uninteresting possibility, given its ambiguity. If *i*) happens to be true, then the denominator of ε_{x^*} tends to increase, decreasing the entire fraction. This is of course working against the $\beta p^{*}{}'(X^*)y^*$ term in the domestic exports elasticity, and vice-versa for the foreign output elasticity. This relationship, while possible, yields no absolute answer without imposing additional conditions.

[11] It should be noted that this inequality would likely not be strict in one instance. With control, y* decreases more than x* rises (see below), and there will be a β where the two expressions equal.

Next, consider possibility *ii*). If *ii*) holds, then we need only concern ourselves with the inequality $\beta p^{*}'(X^{*})y^{*} < p^{*}'(X^{*})x^{*}$. Since this is true, especially with a high β, $\varepsilon_{y^*} < \varepsilon_{x^*}$.

Finally, consider possibility *iii*). If *iii*) is true, then both expressions in the denominator of the foreign output elasticity will be larger than the domestic counterparts, meaning that $\varepsilon_{y^*} < \varepsilon_{x^*}$, given that we already know that the numerator of the foreign output elasticity is smaller than that of the domestic export elasticity.

What is the importance of the foreign elasticity being less than that of domestic output? If *ii*) or *iii*) holds true, and this could also occur in *i*), then there will exist a smaller markup over cost in the foreign market than in the domestic market, according to Brander and Krugman. Thus the export price (price for x^* net of transportation costs) will be less than the price for y^*. The higher price sensitivity for domestic exports causes the domestic firm to dump exports into the foreign market. Given a high responsiveness of its exports to the foreign nation, the home country increases its volume of exports to that country, while the foreign firm must lower its total output to maintain monopoly power: restricting output and increasing price.

It was shown that the acquiring firm increases both domestic output for indigenous consumption and production of exports to the foreign nation. This fact, coupled with the reduced total production of the foreign firm, will yield increased market share to the domestic firm in both markets.

In looking at total output availability in the domestic nation:

$$\frac{\partial X}{\partial \beta} = \frac{-p'(X)[(p(X)-c-t)-\beta(p(X)-c-t)]}{|J|} < 0.$$

This implies that with increasing β, the total output available to the domestic nation will fall. For total output in the domestic nation to fall with increasing ownership, the reductions in foreign exports (y) must outweigh the increase in domestically produced output for indigenous consumption (x). This constriction in output is a standard monopoly result, which will be accompanied by an increase in price.

With respect to the foreign nation, in summary:

$$\frac{\partial x^*}{\partial \beta} > 0, \frac{\partial y^*}{\partial \beta} < 0, \frac{\partial X^*}{\partial \beta} < 0 .$$

Notice that a similar result is occurring in the foreign market. The total output available in that market also falls with increasing β, implying that the price of the foreign output increases as well.

Notice now that net exports in the domestic nation rise, while foreign net exports fall. With respect to the total volume of trade under managerial control, the net volume of trade has again decreased given the directions of x^* and y. Given that both X and X^* again fall with increased ownership in this case, the reduction in y outweighs the increase in x^*. This result is what one would expect. There is now a situation of a world monopoly, where one would expect output constriction. Thus it follows that net trade would fall also.

3.6. Domestic and Foreign Firm Profit:

3.6.A. Non-controlling Interest:

With respect to analyzing the effects on profit when the acquiring firm increases its ownership of the foreign firm, simply differentiate the profit functions with respect to β. For the acquiring firm:

$$(9)\quad \frac{\partial \pi^D}{\partial \beta} = [p'(X)x + \beta p'(X)y]\frac{\partial X}{\partial \beta} + [p^*{}'(X^*)x^* + \beta p^*{}'(X^*)y^*]\frac{\partial X^*}{\partial \beta} + [p(X) - c]\frac{\partial x}{\partial \beta}$$

$$+ [p^*(X^*) - c - t]\frac{\partial x^*}{\partial \beta} + [\beta(p(X) - c - t)]\frac{\partial y}{\partial \beta} + [\beta(p^*(X^*) - c)]\frac{\partial y^*}{\partial \beta} + \pi^F .$$

It is necessary to simplify this expression to evaluate its sign. Knowing that $X = x + y$, and differentiating with respect to β:

$$(10)\qquad \frac{\partial X}{\partial \beta} = \frac{\partial x}{\partial \beta} + \frac{\partial y}{\partial \beta} .$$

Substituting the right-hand side of (10) into (9), its foreign counterpart, and using the first-order conditions (1) through (4) to simplify, (9) becomes:

$$(11)\qquad \frac{\partial \pi^D}{\partial \beta} = p'(X)x\frac{\partial y}{\partial \beta} + p^*{}'(X^*)x^*\frac{\partial y^*}{\partial \beta} - p^*(X^*)\frac{\partial x^*}{\partial \beta} + \pi^F .$$

Notice that the first two terms on the right-hand side are negative, while the latter two terms are positive, indicating that the signing of this partial profit derivative is ambiguous. This should not be surprising to the reader. Remember that in the situation of partial ownership but no control, the domestic firm is sacrificing market share in favor of augmenting the profit of the foreign firm, in which the domestic firm has an interest. These two conflicting forces upon total domestic firm profit lead to the ambiguous result, which was also found by Farrell and Shapiro. They discussed that the profits accruing to the shareholders of the acquiring firm do not necessarily increase in a situation of ownership but no explicit control.

For the partially-acquired foreign firm, differentiating with respect to β:

$$\frac{\partial \pi^F}{\partial \beta} = p'(X)\frac{\partial X}{\partial \beta} y + p^{*}{}'(X^*)\frac{\partial X^*}{\partial \beta} y^* + [p(X) - c - t]\frac{\partial y}{\partial \beta} + [p^*(X^*) - c]\frac{\partial y^*}{\partial \beta}. \tag{12}$$

Substituting (10), its foreign counterpart, and first-order conditions (2) and (4) into (12):

$$\frac{\partial \pi^F}{\partial \beta} = (p'(X)y)\frac{\partial x}{\partial \beta} + (p^{*}{}'(X^*)y^*)\frac{\partial x^*}{\partial \beta} > 0. \tag{13}$$

Notice that this partial derivative can be unambiguously signed as positive, using the previously determined signs of the comparative static results. Given that β and foreign firm profit are positively correlated in this situation, the increased market share of the foreign firm does indeed yield higher profit for that firm. As mentioned earlier, this will indirectly benefit the profit of the domestic firm given the makeup of that firm's profit function.

Concluding Subsection 3.6.A with a formal statement of the next observation:

Proposition 3.4: As the acquiring firm increases its ownership of the foreign firm (but has no external decision-making ability), the foreign firm sees an unambiguous increase in profit, while changes in the profit of the domestic firm are uncertain.

3.6.B. Managerial Control:

The profit derivatives are initially the same in this situation as in subsection A, except that now the simplification is somewhat different. With respect to the acquiring firm, using (10) and its foreign counterpart, and the relevant first-order conditions (5), (6), (7), and (8) into (9):

$$\frac{\partial \pi^D}{\partial \beta} = -p^*(X^*)\frac{\partial x^*}{\partial \beta} + \pi^F .$$

The first term is negative, while the second is positive. However, upon managerial control, the domestic firm is essentially a multi-plant monopoly. With this in mind, $\frac{\partial \pi^D}{\partial \beta} > 0$ to ensure that profits under managerial control (and hence a monopoly) are greater than initially, in other words, symmetric duopoly profits.

With respect to the foreign firm, taking its profit derivative from subsection A., and substituting (10) and its foreign counterpart, (6), and (8) into (12) and rearranging:

$$\frac{\partial \pi^F}{\partial \beta} = (-\frac{p^*{}'(X^*)x^*}{\beta})\frac{\partial y^*}{\partial \beta} - (\frac{p'(X)x}{\beta})\frac{\partial y}{\partial \beta} + p^*{}'(X^*)y^*\frac{\partial x^*}{\partial \beta} + p'(X)y\frac{\partial x}{\partial \beta} < 0 .$$

This partial is unambiguously signed as negative given the comparative static results from Section 3.5. Intuitively then, foreign firm profit is decreasing in β. The foreign firm loses market share in both markets since its total production has been reduced (per the domestic firm), and hence has decreasing profit.

Concluding this subsection with the following proposition:

<u>Proposition 3.5</u>: With managerial control, the domestic firm (now a monopoly) sees an increase in profit with a change in ownership, while the profit of the foreign firm is inversely related with β.

It is surprising that ambiguity is not lost with the assumption of managerial control. One would ordinarily expect ambiguity to disappear in a case where the domestic firm handles all decision-making. But this is not the case, given the makeup of the acquiring firm's profit function, and the two opposing effects on total domestic profit that result. However, economic profits under monopoly (or collusion) are higher than in a duopoly setting. Therefore, this leads us to conclude a positive relationship between β and total domestic firm profit in a setting of managerial control.

3.7. Conclusion:

This chapter has shown what happens to total production, intra-industry trade, and profit of two firms upon changes in asset ownership in a world duopoly, specifically when that ownership is in the form of acquisition of a trading partner. It was seen that with partial ownership but no managerial control, exports of the acquiring nation were

negatively related to changes in ownership, while exports from the foreign firm were positively related. The effect on domestic firm profit was ambiguous, while the foreign firm's profit was found to be positively correlated with β.

Upon the assumption of managerial control, in which only the profit function of the acquiring firm is maximized with respect to each output variable, it was found that exports of the acquiring firm were positively related to changes in ownership. Conversely, total production of the foreign firm fell with increases in β--the exact opposite of what took place in the non-controlling interest situation. This result is due to the higher elasticity of domestic exports relative to the elasticity of foreign production for foreign consumption. Given this, the domestic firm dumps exports into the foreign market, and does not become a textbook multinational. It was also seen that given all the above results, intra-industry trading between the two firms was discouraged upon the acquiring firm increasing its asset holdings of the foreign firm--irrespective to degree of ownership. Total profit of the acquiring firm rises with β, while the relationship between foreign firm profit and β was negative. Thus despite transportation costs and no initial assumption of firm size, the acquiring domestic firm is profitable upon attaining managerial control. This implies that if a firm wishes to expand by acquiring a competitor, it should do so as long as the firm gains managerial control of the competitor. According to U.S. antitrust law, this type of acquisition would perhaps not be discouraged if the resulting merger yields less than seventy-five percent of the market to the integrated firm.

It is generally accepted that acquisition is done to drive out competitors, increase profit, and capture market share. With consideration to the non-controlling interest, the foreign firm is not driven out of the market. In fact, it was seen that the foreign firm's market share actually increases with increasing β. But given the nature of the profit function of the acquiring firm, anything that benefits the profit of the foreign firm will indirectly benefit the acquiring firm. Given a level of β in which managerial control is assumed however, the foreign firm becomes nothing more than a subsidiary of the domestic firm. Upon this action, the economy has moved completely toward a world monopoly with only one independent seller. The acquiring firm directs decisions to the

foreign firm, and uses this monopoly advantage to increase its own profit and market share in both markets, despite the presence of transportation costs.

CHAPTER FOUR
OPTIMAL ASSET OWNERSHIP

4.1. Introduction:

This essay expounds upon the third chapter of this dissertation in that we strive to find an optimal level of ownership when an acquiring firm begins to invest in a foreign competitor. Specifically, this chapter uses the modification of the Brander-Krugman (1983) duopoly model presented in the last chapter to illustrate this optimal level of foreign asset ownership. In deriving the results, it is necessary to refer to the comparative statics and intuition detailed in the third chapter. Ultimately, the optimal level of foreign investment is a degree in which total ownership is attained. In other words, the optimal level of ownership is when the acquiring firm not only obtains managerial control of its foreign competitor, but absolute ownership of that firm. If this is the case, then why do we observe some firms in the real world obtaining only non-controlling interests in other firms? If it is optimal to own all of a foreign firm, then why do not all firms do this?

In some instances, such as with the presence of antitrust legislation or endogenous protection, total ownership is not allowed or is not feasible. In this case, the acquiring firm should obtain the maximum allowable ownership of its competitor. Additionally, both foreign national welfare and domestic national welfare most likely fall upon increased asset ownership by the domestic firm.

Recall the problem encountered in the third chapter with respect to changes in domestic firm profit with increases in ownership. When taking the ownership parameter exogenously, no matter if the domestic firm obtained a non-controlling share or a share in which managerial control could be assumed, the acquiring firm faced an ambiguous change in total firm profit with a given change in ownership. By assumption, profit must be higher for a firm upon reaching a monopoly position. In the model presented in the third chapter, there were only two firms. By basic economic theory, monopoly profits (those achieved with managerial control) must be higher than duopoly profits. Total domestic firm profit is the summation of the domestic firm's own internal operations from operating domestically (as well as exporting abroad) and the profits accrued from its share in the foreign firm. The ambiguity is of no surprise, even in the managerial control setting. With non-controlling interest, the domestic firm lowers its production in favor of

augmenting the profits from its foreign direct investment. Therefore, profits from domestic operation fall, while profits from the share of the foreign firm rise, given that the foreign firm increases production to compensate. These two effects work against each other in the makeup of the domestic firm's total profit function. Expressing the ownership parameter as β, this profit function is expressed as:

$$(1) \qquad \pi^D = \pi^O + \beta\pi^F,$$

where: D denotes the Domestic (acquiring) firm's total profit function

O denotes the acquiring firm's Own internal profit

F denotes the Foreign firm's profit function

$\beta \in [0,1]$.

As can be seen in (1), with non-controlling interest, π^O is falling in β, while π^F is increasing. As mentioned above, as the domestic firm increases its ownership of the foreign firm, it lowers production in order to augment its return from its investment. The domestic firm yields production to the foreign firm. As the foreign firm increases its production to compensate for the lower domestic output, the foreign firm observes an increase in profit. Given that the domestic firm has an ownership stake in the foreign firm, the domestic firm will recognize an increase in its profit as well. Thus the total effect on π^D would be ambiguous.

Under the managerial control situation, it is π^O that increases in β, while π^F falls. Recall that with managerial control, the domestic firm increases its total output, while dictating that the foreign firm reduces its total output. This of course adversely affects the foreign firm's profit. In this situation, π^O and π^F are again working against each other, resulting in ambiguity of π^D.

Given this, there is a need to continue with the analysis of firm profit and asset ownership. Therefore, it is no longer assumed that β is a given exogenous variable, but is now endogenous. The domestic firm will then maximize its total profit with respect to β, choosing that level of ownership which maximizes its total profit. In deriving these results, the comparative statics from Chapter Three will be called upon.

This chapter approaches the problem from a basic game theoretic standpoint. Assume a one-shot Cournot-Nash game composed of two stages. In the first stage, the

domestic firm chooses its optimal level of ownership, or its β. This level of ownership takes a value in the interval [0,1]. When $\beta = 0$, the domestic firm has no investment in the foreign firm. When $\beta = 1$, the domestic firm has total and absolute ownership in the foreign firm, hence having managerial control. There is a level of β, denoted as $\tilde{\beta}$, in which the domestic firm acquires a majority ownership and thus managerial control of the foreign firm. In the second stage, the two firms play Cournot in outputs. Backward induction is used to solve the model and find the subgame perfect Nash equilibrium that results. This analysis is pursued in Section 4.2. Section 4.3 presents the problem from an antitrust perspective. In Section 4.4, the effects on country welfare are illustrated using Brander-Krugman welfare functions. Section 4.5 provides concluding remarks.

4.2. Optimal Ownership:

In analyzing the one-shot Cournot-Nash game, backward induction is used to find the optimal level of ownership that the domestic firm will acquire. Allow $p(X)$ and $p^*(X^*)$ to be the domestic and foreign prices of output, respectively. The two firms produce identical products at identical marginal costs. Both firms export to the other country at the same transportation cost, t. Additionally, x^* and y are the exports of the domestic firm and the foreign firm, respectively. Furthermore, x is domestic output produced for domestic consumption, while y^* is foreign output produced for foreign consumption. Lastly, $X = x + y$, and $X^* = x^* + y^*$. X is the total output available in the domestic market, and X^* is the total output available in the foreign country. At the outset of the game, the two firms are symmetric. Presenting the specific profit functions of the world duopoly once again:

(2) $$\pi^D = p(X)x + p^*(X^*)x^* - cx - cx^* - tx^* + \beta[p^*(X^*)y^* + p(X)y - cy^* - cy - ty]$$

and

(3) $$\pi^F = p^*(X^*)y^* + p(X)y - cy^* - cy - ty.$$

The key variable in this revision of the Brander-Krugman model is the β term in (2)--the degree of ownership variable. As far as purchasing the additional shares of the foreign firm, no explicit term in the profit function in (2) is presented. In the third chapter, it was simply stated that additional firm ownership could be thought of as a fixed cost.

Additionally, the domestic firm will not acquire a level of β which makes it worse off. As long as the marginal revenue from additional β is greater than the marginal cost, there is no need to make a specific notation in the profit function above for the cost of acquiring ownership.

In the second stage, the two firms play Cournot. The results of the second stage would simply be the argmax of (2) and (3), yielding the solution $\{\hat{x}, \hat{x}^*, \hat{y}, \hat{y}^*\}$. This solution represents the Nash output of the domestic firm for domestic consumption, domestic exports, foreign exports, and the foreign firm's production for foreign consumption, respectively.

In solving the first stage, the profit functions above must be revisited. Recall that the objective in this stage is to find the *optimal* level of ownership for the domestic firm. At this point, it is still not known whether the domestic firm will acquire up to a level of managerial control or not. Given that β can take a value between zero and one, and the fact that the profit function is nonlinear, Kuhn-Tucker programming is used. The optimization problem is:

$$\{\beta\} \text{ Max } \pi^D \text{ subject to } 0 \leq \beta \leq 1;\ \{x, x^*, y, y^* > 0\}.$$

Notice the constraint. Again, β must take a value between zero and one.

This optimization is not without a potential problem. It is highly likely that the domestic profit function is discontinuous at the level of β in which managerial control of the foreign firm is achieved. Therefore, the problem must be modified further. Thus the optimization problem should be:

$$(4) \qquad \{\beta\} \text{ Max } \pi^D \text{ subject to } 0 \leq \beta \leq \tilde{\beta};\ \{x, x^*, y, y^* > 0\}$$

and

$$(5) \qquad \{\beta\} \text{ Max } \pi^D \text{ subject to } \tilde{\beta} \leq \beta \leq 1;\ \{x, x^*, y, y^* > 0\}.$$

4.2.A. Non-controlling Interest:

Taking this setting first, equation (4) is of concern in order to formulate the Lagrangian. Therefore (2) is modified as follows:

$$(6) \qquad \Lambda_1 = p(X)x + p^*(X^*)x^* - cx - cx^* - tx^* + \beta\pi^F + \lambda_1(\tilde{\beta} - \beta)$$

where: Λ_1 = the Lagrangian function to be maximized

λ_1 = the Lagrangian multiplier.

Upon differentiating, we must use the first-order conditions, the comparative statics results from the third chapter, and $\beta = 0$. The first-order conditions are re-presented:

$$\frac{\partial \pi^D}{\partial x} = p'(X)x + p(X) - c + \beta p'(X)y = 0 \ ,$$

$$\frac{\partial \pi^F}{\partial y} = p'(X)y + p(X) - c - t = 0 \,,$$

$$\frac{\partial \pi^D}{\partial x^*} = p^*{}'(X^*)x^* + p^*(X^*) - c - t + \beta p^*{}'(X^*)y^* = 0 \,,$$

$$\frac{\partial \pi^F}{\partial y^*} = p^*{}'(X^*)y^* + p^*(X^*) - c = 0 \,.$$

Taking the first-order necessary conditions and simplifying:

$$(7.1) \qquad \begin{aligned} \frac{\partial \Lambda_1}{\partial \beta} = &-\frac{\partial y}{\partial \beta} p(X)(1-\beta) + \frac{\partial y}{\partial \beta} c(1-\beta) - \frac{\partial y^*}{\partial \beta} p^*(X^*)(1-\beta) + c\frac{\partial y^*}{\partial \beta}(1-\beta) \\ &+ t(\frac{\partial y^*}{\partial \beta} - \beta \frac{\partial y}{\partial \beta}) + y^*(p^*(X^*) - c) + y(p(X) - c - t) - \lambda_1 \le 0. \end{aligned}$$

(7.1) must be less than or equal to zero for a maximum. If the partial derivative were greater than zero, the domestic profit function would be increasing in β meaning that the function would be upward-sloping. Thus the conditions for a global maximum will not be met with respect to the choice variable β. The remaining Kuhn-Tucker conditions are:

$$(7.2) \qquad (\frac{\partial \pi^D}{\partial \beta} - \lambda_1)\beta = 0 \,,$$

$$(7.3) \qquad \beta \ge 0 \,,$$

$$(8.1) \qquad \frac{\partial \Lambda_1}{\partial \lambda_1} = \tilde{\beta} - \beta \ge 0 \,,$$

$$(8.2) \qquad (\tilde{\beta} - \beta)\lambda_1 = 0 \,,$$

$$(8.3) \quad \lambda_1 \geq 0 .$$

When using Kuhn-Tucker programming, the constraint needs to be differentiable and convex for a maximum. Since the constraint is linear, the constraint qualification is satisfied. Thus, the Kuhn-Tucker conditions are necessary and sufficient as long as the objective function, π^D, is concave and differentiable.

If the non-controlling interest problem is evaluated at $\beta = 0$, this implies that $(\tilde{\beta} - \beta) > 0$. Given (8.2), λ_1 must equal zero for $(\tilde{\beta} - \beta)\lambda_1 = 0$. Thus in (7.1), λ_1 drops out when evaluating at $\beta = 0$.

With respect to the comparative statics results from Chapter Three, in a situation of non-controlling interest, $\frac{\partial X}{\partial \beta}, \frac{\partial X^*}{\partial \beta}, \frac{\partial x}{\partial \beta}, \frac{\partial x^*}{\partial \beta} < 0$, and $\frac{\partial y}{\partial \beta}, \frac{\partial y^*}{\partial \beta} > 0$. Additionally, recall that $X = x + y$, and $X^* = x^* + y^*$.

Rearranging the first-order conditions, and substituting into (7.1), the expression in (7.1) simplifies to:

$$(9) \qquad \begin{aligned} \frac{\partial \Lambda_1}{\partial \beta} &= -\frac{\partial y}{\partial \beta}(p(X) - c) - \frac{\partial y^*}{\partial \beta}(p^*(X^*) - c - t) + \\ & y^*(p^*(X^*) - c) + y(p(X) - c - t) \leq 0. \end{aligned}$$

When $\beta = 0$, $\frac{\partial \Lambda_1}{\partial \lambda 1} = \tilde{\beta} > 0$ from (8.1). It has already been shown that λ_1 must equal zero when β equals zero from (8.2). Therefore, from (8.3), $\lambda_1 \geq 0$, which satisfies the last of the constraints. If β and λ_1 both equal zero, $\frac{\partial \pi^D}{\partial \beta}$ may or may not equal zero with respect to (7.2). But from (7.1), $\frac{\partial \Lambda_1}{\partial \beta} = \frac{\partial \pi^D}{\partial \beta} - \lambda_1 \leq 0$. Since λ_1 equals zero, $\frac{\partial \pi^D}{\partial \beta} \leq 0$. Thus at $\beta = 0$, the domestic profit function is decreasing in β.

What about a level of β such that $0 < \beta < \tilde{\beta}$? With respect to (8.1), $\frac{\partial \Lambda_1}{\partial \lambda_1} = \tilde{\beta} - \beta > 0$. Since $(\tilde{\beta} - \beta) > 0$, λ_1 must equal zero for (8.2) to hold true. Since $\lambda_1 = 0$, (8.3) is satisfied.

When evaluating (7.1) with a positive level of β in the non-controlling interest problem, $(\frac{\partial \pi^D}{\partial \beta} - \lambda_1) = 0$ per (7.2). Since λ_1 is zero, $\frac{\partial \pi^D}{\partial \beta} = 0$. Therefore, at positive levels of β below $\tilde{\beta}$, the profit function has a local minimum. Recall that when $\beta = 0$, the profit function was less than or equal to zero.

Lastly, evaluate (7.1) at a level of β equal to $\tilde{\beta}$. In this case, (8.1) equals zero, meaning that λ_1 must be greater than or equal to zero according to (8.2), which in turn satisfies (8.3). Since β is positive, (7.2) reveals that $(\frac{\partial \pi^D}{\partial \beta} - \lambda_1) = 0$. Because $\lambda_1 \geq 0$, this means that $\frac{\partial \pi^D}{\partial \beta} \geq 0$. Thus, the domestic profit function may be upward sloping from $\tilde{\beta}$. Refer to Figure 4.1 below for a graphical representation of domestic profit as a function of β.

4.2.B. Managerial Control:

Turning next to the ownership with control setting, the optimization problem is now described by (5) above. Formulating the Lagrangian, the optimization problem with managerial control is:

$$(10) \qquad \Lambda_2 = p(X)x + p^*(X^*)x^* - cx - cx^* - tx^* + \beta\pi^F + \lambda_2(1-\beta) + \lambda_3(\beta - \tilde{\beta}).$$

It was mentioned in the last chapter that when a firm has managerial control over another, the acquiring firm's profit function is to be maximized with respect to all output variables.

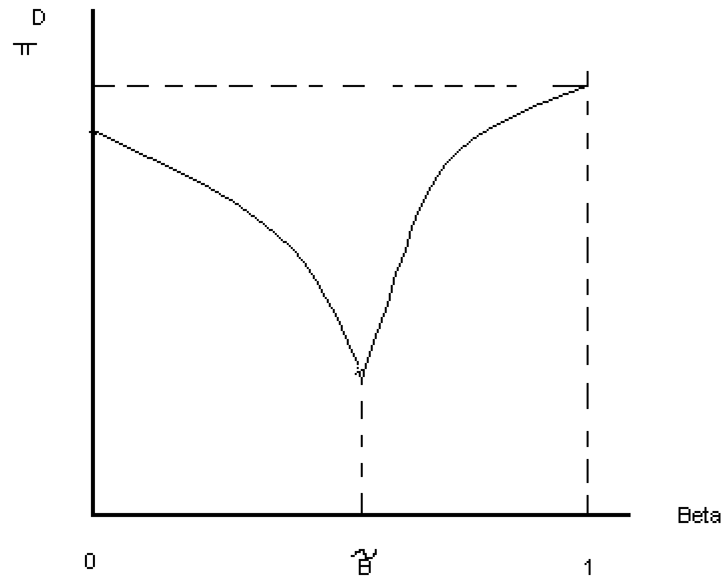

Figure 4.1—Domestic Profit and Ownership

Re-presenting the first-order conditions under managerial control from the last chapter:

$$\frac{\partial \pi^D}{\partial x} = p'(X)x + p(X) - c + \beta p'(X)y = 0\,,$$

$$\frac{\partial \pi^D}{\partial y} = p'(X)x + \beta p'(X)y + \beta\,(p(X) - c - t) = 0\,,$$

$$\frac{\partial \pi^D}{\partial x^*} = p^*{}'(X^*)x^* + p^*(X^*) - c - t + \beta p^*{}'(X^*)y^* = 0\,,$$

$$\frac{\partial \pi^D}{\partial y^*} = p^*{}'(X^*)x^* + \beta p^*{}'(X^*)y^* + \beta\,(p^*(X^*) - c) = 0\,.$$

Thus the first-order necessary (and sufficient for reasons mentioned above) condition is:

$$(11.1)\quad \frac{\partial \Lambda_2}{\partial \beta} = -\frac{p^*{}'(X^*)x^*}{\beta}y^* - \frac{p'(X)x}{\beta}y - p^*{}'(X^*)y^{*2} - p'(X)y^2 - \lambda_2 + \lambda_3 \le 0\,.$$

For a maximum, (11.1) must be less than or equal to zero. The remaining Kuhn-Tucker conditions are:

$$(11.2)\quad \left(\frac{\partial \pi^{D}}{\partial \beta} - \lambda_2 + \lambda_3\right)\beta = 0,$$

$$(11.3)\quad \beta \geq 0,$$

$$(12.1)\quad \frac{\partial \Lambda_2}{\partial \lambda_2} = 1 - \beta \geq 0,$$

$$(12.2)\quad (1 - \beta)\lambda_2 = 0,$$

$$(12.3)\quad \lambda_2 \geq 0,$$

$$(13.1)\quad \frac{\partial \Lambda_2}{\partial \lambda_3} = \beta - \tilde{\beta} \geq 0,$$

$$(13.2)\quad (\beta - \tilde{\beta})\lambda_3 = 0,$$

$$(13.3)\quad \lambda_3 \geq 0.$$

It is necessary first to evaluate (11.1) where $\beta = \tilde{\beta}$. With respect to the two multipliers, (12.2) requires that $\lambda_2 = 0$, which satisfies (12.3). With respect to (13.1), it is zero when $\beta = \tilde{\beta}$. This means that $\lambda_3 \geq 0$. In (11.2), since β is positive, $(\frac{\partial \pi^{D}}{\partial \beta} + \lambda_3) = 0$. Since the multiplier is greater than or equal to zero, $\frac{\partial \pi^{D}}{\partial \beta} \leq 0$. Looking at (11.1), all terms are positive, which violates the Kuhn-Tucker conditions, meaning that π^{D} increases as β increases.

Next, evaluate $\frac{\partial \Lambda_2}{\partial \beta}$ at some $\tilde{\beta} < \beta < 1$. First of all, with respect to the constraint and multipliers, β is positive, but does not equal one. Referring to (12.2), $(1 - \beta) > 0$, meaning that for (12.2) to hold, λ_2 must equal zero, which in turn satisfies (12.3). Considering the third Lagrangian multiplier, since a level of ownership concerning managerial control is greater than $\tilde{\beta}$, $(\beta - \tilde{\beta}) > 0$. As a result, λ_3 must equal zero in order for (13.2) to hold true, meaning that (13.3) is satisfied. Therefore in evaluating (11.1), the multipliers drop out of the expression. This means that $\frac{\partial \pi^{D}}{\partial \beta} = 0$ with respect

to (11.2). Again, this violates the Kuhn-Tucker condition, since (11.1) is known to be positive.

Lastly, (11.1) should be evaluated where $\beta = 1$, in other words, where the domestic firm has acquired total ownership of the foreign firm. First of all, with respect to the constraints and the multipliers, (12.1) will be zero whenever β equals one. Looking at (12.2), since (12.1) equals zero, $\lambda_2 \geq 0$, satisfying (12.3). Additionally, (13.1) will be $(1 - \tilde{\beta}) > 0$. This implies that $(\beta - \tilde{\beta}) > 0$, which means that with respect to (13.2), λ_3 must equal zero. This in turn satisfies (13.3), which states that λ_3 must be greater than or equal to zero. This now allows us to simplify the expression in (11.1). Accordingly:

$$(14) \qquad \frac{\partial \Lambda_2}{\partial \beta} = -p^{*}{'}(X^{*})x^{*}y^{*} - p'(X)xy - p^{*}{'}(X^{*})y^{*2} - p'(X)y^{2} - \lambda_2 = 0.$$

Notice that (14) holds with equality, since the value of β is positive and assumed to be one here, which is the maximum value that parameter can take. Referring back to (11.2), since $\lambda_3 = 0$ and $\lambda_2 \geq 0$, (11.2) is reduced to $(\frac{\partial \pi^D}{\partial \beta} - \lambda_2)\beta = 0$. Since $\beta = 1$ in the present analysis, (11.2) becomes $(\frac{\partial \pi^D}{\partial \beta} - \lambda_2) = 0$. For (11.2) to hold when $\lambda_2 \geq 0$, this means that $\frac{\partial \pi^D}{\partial \beta} \geq 0$. Therefore, domestic profit is positively related with ownership when β equals one. Again, this violates the Kuhn-Tucker conditions. Since $\frac{\partial \pi^D}{\partial \beta} > 0$ at levels of β greater than or equal to $\tilde{\beta}$ in the managerial control setting, π^D is upward-sloping to $\beta = 1$ when the multiplier is positive. This implies that π^D is monotonically increasing in β whenever $\tilde{\beta} \leq \beta \leq 1$. Refer back to Figure 4.1 to see the remainder of the diagram concerning managerial control.

Optimal asset ownership will be where the profit function is at its highest point, in other words, at a point of global maximum. Since $\frac{\partial \pi^D}{\partial \beta} \leq 0$ when $\beta = 0$, it is highly

unlikely that the global maximum is where $\beta = 0$. Global maximums are rarely located on a vertical intercept where the curve extending from that intercept is downward sloping. Additionally, looking at $\frac{\partial \Lambda_1}{\partial \beta}_{|\beta=0}$ and $\frac{\partial \Lambda_2}{\partial \beta}_{|\beta=1}$, it appears that the latter point will be higher. In other words, profit is higher when $\beta = 1$ as opposed to when $\beta = 0$. Thus, there is a boundary solution. When $\beta = 1$, this is a situation of a multiplant monopoly on behalf of the domestic firm. When $\beta = 0$, this is a symmetric duopoly. Monopoly profits will be higher than duopoly profits. Thus economic theory dictates that the profit point corresponding with $\beta = 1$ will be higher than the point corresponding with $\beta = 0$. Note the plotted points in Figure 4.1.

Concluding this section with the first summary proposition:

Proposition 4.1: The optimal level of ownership in the Brander-Krugman reciprocal dumping model is a level in which the acquiring firm has total and absolute ownership (and hence managerial control) of its foreign competitor.

4.3. Antitrust Considerations:

It is really of no surprise that the optimal level of ownership for a firm to acquire is such that will give that firm a monopoly position. Therefore we must ask ourselves, why do firms sometimes "settle" for a level of ownership which yields only a non-controlling interest? In the United States, horizontal integration, as was detailed in this essay and in a preceding chapter, is not without strict oversight and regulation from the Federal Trade Commission and the Antitrust Division of the Department of Justice. Horizontal acquisitions which inhibit competition are deemed "illegal per se," which is to say that they are against the law because of their very nature. In a simple model such as this presented here, any government with antitrust legislation would likely not allow a firm in the United States to merge with a firm in another country. The results seen were restrictions of output that would lead to higher prices in the United States. These higher prices would harm consumers, while at the same time yielding monopoly profits to producers. In this case, the government would most definitely intervene to prevent the merger from ever taking place. Given antitrust concerns then, governments would not allow monopolies to form. With this in mind, β cannot equal one.

Alternatively, some foreign nations may wish to remain highly nationalized, although they still try and attract international investment. The People's Republic of China is such a nation, despite its "open door" policy. Potential investors must be met with government approval. In certain sectors such as advertising, transportation, brokerage, and publishing, foreign investment is highly restricted, no matter how much potential investment is desired. China deems certain industries as "strategic," and protection of national interests outweighs potential benefits from inflows of foreign investment.[12]

Not only are there governmental concerns about international investment into China, there are also concerns expressed by U.S. firms. In a survey reported by the web site *China Today*, the major challenges Americans face in doing business in China is red-tape and bureaucracy (see Table 4.1).[13]

Table 4.1
Challenges to Americans Regarding Business in China

Permission to enter market	38%
Bankruptcy	42%
Transparency	43%
Human Resources	56%
Red-tape and bureaucracy	67%

With this in mind, the model above is reconstructed, and renamed the "China model." In the China model, allow there to be a maximum level of ownership allowed by the government. Denote this level of ownership as β^A, which is the maximum allowable ownership of Chinese firms by a foreign nation, such as the United States (one could also deem this level of ownership as "antitrust" in the United States, hence the "A"). In the China model, allow the maximum allowable ownership to be below that level of β in

[12] Jon Eichelberger and Annabel Allen, "A Legal Perspective: The Impact of WTO on Foreign Investment in China's Internet/E-Commerce Sector," 13 July 2001, <http://www.perkinscoie.com/resource/intldocs/wtoimpact.htm>, Perkins Coie LLP, (16 March 2002).
[13] *White Paper of 2000* issued by China American Merchants Association, "The Major Challenges Americans are Facing in Doing Business in China," <http://www.chinatoday.com/inv/a.htm>, (16 March 2002).

which managerial control is assumed, $\tilde{\beta}$. The spectrum of ownership now looks like the following illustration:

$$\bullet - - - - - | - - - | - - - - - - \bullet$$

$$0 \qquad\quad \beta^{A} \quad\; \tilde{\beta} \qquad\quad 1 \qquad .$$

The Lagrangian is now also different with respect to the constraint in the Kuhn-Tucker maximization problem. Looking at the problem from strictly a non-controlling interest point of view, the Lagrangian is now expressed as:

$$(15) \qquad \{\beta\} \ \ \text{Max } \pi^{D} \text{ subject to } 0 \le \beta \le \beta^{A}.$$

Optimization problem (15) concerns a non-controlling interest and maximum allowable ownership. It is necessary to diagram the profit function over this allowable region of ownership to illustrate that level which the domestic firm would purchase. In other words, the level of ownership that provides the highest level of profit for the domestic firm, keeping in mind that forming a monopoly is no longer an option.

Defining (15) in more specific terms:

$$(16) \qquad \Lambda_3 = \pi^{D} + \lambda_4(\beta^{A} - \beta).$$

The first-order necessary conditions are essentially the same as group (7) above:

$$(17.1) \quad \begin{aligned} \frac{\partial \Lambda_3}{\partial \beta} &= -\frac{\partial y}{\partial \beta}(1-\beta)(p(X)-c) - \frac{\partial y^*}{\partial \beta}(1-\beta)(p^*(X^*)-c) + y^*(p^*(X^*)-c) \\ &+ y(p(X)-c-t) + t(\frac{\partial y^*}{\partial \beta} - \beta\frac{\partial y}{\partial \beta}) - \lambda_4 \le 0, \end{aligned}$$

$$(17.2) \quad (\frac{\partial \pi^{D}}{\partial \beta} - \lambda_4)\beta = 0,$$

$$(17.3) \quad \beta \ge 0,$$

$$(18.1) \quad \frac{\partial \Lambda_3}{\partial \lambda_4} = \beta^{A} - \beta \ge 0,$$

$$(18.2) \quad (\beta^{A} - \beta)\lambda_4 = 0,$$

$$(18.3) \quad \lambda_4 \ge 0.$$

As before, first evaluate the problem at $\beta = 0$. With zero level of ownership, $(\beta^{A} - \beta) > 0$, meaning that λ_4 must equal zero for (18.2) to hold, which satisfies (18.3). Referring to (17.2), $\frac{\partial \pi^{D}}{\partial \beta}$ must then be less than or equal to zero.

Evaluating (17.1) where the level of ownership is $0 < \beta < \beta^{A}$, (18.1) will be positive, meaning that with respect to (18.2), λ_4 must equal zero, which satisfies (18.3). With this, (17.2) can now be solved. With a positive level of β (yet unequal to β^{A}), $\frac{\partial \pi^{D}}{\partial \beta} = \lambda_4 = 0$.

Lastly, evaluate the problem at the level of maximum allowable ownership, $\beta = \beta^{A}$. Again, the positive β means that (18.1) is solved with an equality. With this, $\lambda_4 \geq 0$ according to (18.2). Since $\beta > 0$, $(\frac{\partial \pi^{D}}{\partial \beta} - \lambda_4)$ must equal zero in (17.2). Since $\lambda_4 \geq 0$, $\frac{\partial \pi^{D}}{\partial \beta}$ must be greater than or equal to zero, implying that domestic profit increases in β (with a positive multiplier) at the maximum level of ownership allowed by China, β^{A}.

What is needed now is to compare the two points, $\beta = 0$ and $\beta = \beta^{A}$. These are the only two points of interest since π^{D} declines from a zero level of ownership and may be positively sloped at β^{A}. However, it is not known from the above whether the profit point associated with $\beta = 0$ is below or above the profit point associated with $\beta = \beta^{A}$. In order to better analyze this, the model must be modified somewhat.

Specifically, we will add another constraint to the model already presented. Impose a constraint such that any investment by the domestic firm must be a level in which the profit from that investment $(\beta\pi^{F})$ is greater than or equal to the lost profit from reducing output in favor of the acquisition (π^{O}) (recall the non-controlling interest argument). This will cause π^{D} to be greater than or equal to zero, and investment by the domestic firm will be profitable.

The problem is now:

$$\{\beta\} \quad \text{Max } \pi^{D} \text{ subject to } 0 \le \beta \le \beta^{A} \text{ and subject to } \beta\pi^{F} \ge \pi^{O} \ (\pi^{D} \ge 0).$$

Formulating the new Lagrangian:

$$\Lambda_4 = \pi^{O} + \beta\pi^{F} + \lambda_5(\beta^{A} - \beta) + \lambda_6(\beta\pi^{F} - \pi^{O}).$$

The Kuhn-Tucker conditions are:

$$(19.1) \quad \frac{\partial \Lambda_4}{\partial \beta} = \frac{\partial \pi^{O}}{\partial \beta} + \pi^{F} + \beta\frac{\partial \pi^{F}}{\partial \beta} - \lambda_5 + \lambda_6\pi^{F} - \lambda_6\frac{\partial \pi^{O}}{\partial \beta} \le 0,$$

$$(19.2) \quad \left(\frac{\partial \pi^{O}}{\partial \beta} + \pi^{F} + \beta\frac{\partial \pi^{F}}{\partial \beta} - \lambda_5 + \lambda_6\pi^{F} - \lambda_6\frac{\partial \pi^{O}}{\partial \beta}\right)\beta = 0,$$

$$(19.3) \quad \beta \ge 0,$$

$$(20.1) \quad \frac{\partial \Lambda_4}{\partial \lambda_5} = \beta^{A} - \beta \ge 0,$$

$$(20.2) \quad (\beta^{A} - \beta)\lambda_5 = 0,$$

$$(20.3) \quad \lambda_5 \ge 0,$$

$$(21.1) \quad \frac{\partial \Lambda_4}{\partial \lambda_6} = \beta\pi^{F} - \pi^{O} \ge 0,$$

$$(21.2) \quad (\beta\pi^{F} - \pi^{O})\lambda_6 = 0,$$

$$(21.3) \quad \lambda_6 \ge 0.$$

It is necessary to evaluate these conditions just as before. Starting first with $\beta = 0$, and looking at the first multiplier, if there is zero ownership, (20.1) is positive. This means that for (20.2) to hold, λ_5 must equal zero. With respect to the second multiplier, if $\beta = 0$, then (21.1) reduces to $-\pi^{O}$, which is negative, violating the second constraint. Quite obviously with the constraint of ownership yielding nonnegative total domestic profit, β cannot be zero. Therefore, $\beta > 0$, and (19.1) is solved with an equality.

The constraint of ownership yielding nonnegative total domestic profit is not an unfeasible one. Recall that the domestic firm is reducing its total output in order to augment the profits of its investment into the foreign firm (which is increasing its total output). Total domestic profit will fall with an incremental level of ownership, but total domestic profit will eventually increase due to the increased profitability of the foreign

firm as ownership increases. This higher foreign profit will eventually outweigh the lost domestic profit from reduced domestic production. The second constraint is imposed to simply narrow the choice of β. In other words, to ignore those levels of ownership that are not profitable for the domestic firm.

Evaluating this maximization problem where $0 < \beta < \beta^A$, it is seen that (20.1) is greater than zero, meaning that λ_5 must equal zero. With respect to (21.1), a positive level of β helps to satisfy this constraint by the precondition described above, in regard to only profitable levels of ownership. This will require that $\lambda_6 = 0$ for (21.2) to hold. This means that (19.1) simplifies to $\frac{\partial \Lambda_4}{\partial \beta} = \frac{\partial \pi^O}{\partial \beta} + \pi^F + \beta \frac{\partial \pi^F}{\partial \beta}$. Additionally, since $\beta > 0$, this expression must equal zero for (19.2) to be satisfied.

Lastly, evaluate this problem when $\beta = \beta^A$, the maximum level of allowable ownership in the China model. In this case, (20.1) equals zero, meaning that $\lambda_5 \geq 0$. (21.1) is again positive with the precondition of profitability, meaning that $\lambda_6 = 0$ for (21.2) to hold. With these results, (19.1) simplifies to $\frac{\partial \Lambda_4}{\partial \beta} = \frac{\partial \pi^O}{\partial \beta} + \pi^F + \beta \frac{\partial \pi^F}{\partial \beta} - \lambda_5$. A positive level of β again means that this expression must hold with equality for (19.2) to be satisfied (the complementary slackness condition).

Notice that the two expressions for $\frac{\partial \Lambda_4}{\partial \beta}$ differ by the multiplier $-\lambda_5$, and this multiplier is greater than or equal to zero. If the multiplier equals zero, then $\beta < \beta^A$. If the multiplier is positive, then $\beta = \beta^A$. Since the optimal level of ownership is when $\beta > 0$, (19.1) holds with equality, and hence $\frac{\partial \pi^O}{\partial \beta} + \pi^F + \beta \frac{\partial \pi^F}{\partial \beta} = \lambda_5$. The left hand side is simply $\frac{\partial \pi^D}{\partial \beta}$, and is positive if λ_5 is positive. Therefore, when $\beta = \beta^A$, $\lambda_5 \geq 0$ meaning that $\frac{\partial \pi^D}{\partial \beta} \geq 0$. Thus at the maximum allowable ownership of the foreign firm, the domestic profit function may be upward-sloping, meaning that domestic profit could

be positively-correlated with ownership. At all levels of ownership below this point β^A then, the profit function lies below this point. This leads us to conclude that the domestic firm will acquire ownership in the foreign firm up to the maximum level, β^A.

It may surprise the reader that a global maximum is found where the profit function is increasing. But recall this is a boundary solution. A global maximum of a function is not found when a function is upward sloping and there is no constraint other than non-negativity. In this problem, there is an additional constraint. Recall $0 \leq \beta \leq \beta^A$. Above, $0 \leq \beta \leq 1$ was imposed. In both cases, a boundary solution was obtained, with the domestic firm purchasing the maximum possible amount of ownership in the foreign firm.

What if there are no antitrust considerations in the foreign (or domestic) nation? Why might a level of non-controlling ownership be obtained versus the level that yields a multiplant monopoly? The two nations in the modified version of the Brander-Krugman reciprocal dumping model are trading partners. What if the foreign nation were to become protectionist when the domestic firm obtains a certain level of ownership? Suppose that in the model above, some level of ownership is obtained by the domestic firm that is above the level of managerial control. Recall that with a controlling interest, the domestic firm increases its exports to the foreign nation while at the same time directing the foreign firm to reduce its total output. If the foreign government fears further invasion of its market by the domestic firm, it may levy heavy tariffs on domestic exports. Ceteris paribus, this adversely affects domestic profit. Similar intuition holds if the protectionism stems from a certain level of non-controlling interest being acquired. Tariffs imposed on domestic exports will lower π^O (as will the increased level of ownership). In other words, these conclusions can be reached in an endogenous protection setting as well.

Presenting the next proposition:

Proposition 4.2: In an antitrust or nationalist setting where managerial control or monopolies are not allowed, the optimal level of ownership is that in which the domestic firm obtains as much of the foreign firm as allowed by the foreign government.

4.4. Welfare:

In analyzing welfare, Brander-Krugman welfare functions are used to illustrate changes in both domestic and foreign welfare with changes in asset ownership. Allowing W^D to denote domestic country welfare, and W^F to denote welfare of the foreign nation, present the functions as:

$$(22) \qquad W^D = u(X) - cx - cx^* - tx^* + \beta\pi^F ,$$

$$(23) \qquad W^F = u^*(X^*) - cy^* - cy - ty .$$

Given that the optimal merger is one in which the acquiring firm has absolute and total ownership, it is necessary to differentiate (22) and (23) with this setting in mind. Differentiating these two expressions with respect to β reveals:

$$(24) \qquad \frac{\partial W^D}{\partial \beta} = p(X)\frac{\partial X}{\partial \beta} - c\frac{\partial x}{\partial \beta} - \frac{\partial x^*}{\partial \beta}(c+t) + \pi^F + \beta\frac{\partial \pi^F}{\partial \beta} ,$$

$$(25) \qquad \frac{\partial W^F}{\partial \beta} = p^*(X^*)\frac{\partial X^*}{\partial \beta} - c\frac{\partial y^*}{\partial \beta} - \frac{\partial y}{\partial \beta}(c+t) .$$

Let us analyze (25) first. Assume that $u(X)$ and $u^*(X^*)$ are quasi-linear utility functions for the home country and the foreign country, respectively. Keeping in mind that the derivatives of these functions with respect to output will simply yield the output price, the first expressions of the right-hand sides of (24) and (25) are negative. Since $\frac{\partial y}{\partial \beta}$ and $\frac{\partial y^*}{\partial \beta}$ are both negative in the controlling interest situation, the last two expressions on the right are both positive. Thus, foreign welfare likely falls as the domestic firm acquires total ownership in the foreign firm. The intuition for this result, although ambiguous, is as follows. Recall that the foreign firm is decreasing its output and hence its profit in response to the higher total domestic output. The foreign firm decreases its share in both the domestic and the foreign markets. Additionally, since $\frac{\partial X}{\partial \beta}$ and $\frac{\partial X^*}{\partial \beta}$ are both negative, price will increase in both markets with this output restriction. This price increase adversely affects consumers. Consumer utility falls with higher output prices.

With respect to (24), the result is ambiguous, but appears to most likely be negative. Only the fourth term on the right-hand side is positive, while the remaining terms are negative. Again, there is a negative effect on welfare from the higher output prices in the domestic market, which harms consumers. The domestic firm's total profit has been optimized in the majority ownership situation. If the positive welfare effects from the domestic firm's activities are outweighed by the negative effects of higher prices on domestic consumers, then total welfare in the home nation will decrease with respect to increased and absolute foreign asset ownership. Welfare in the domestic country likely falls upon the attainment of managerial control by the domestic firm due to the world economy moving from a duopoly to a multiplant monopoly. This high monopoly distortion (restricted output and higher prices) leads to welfare reduction in the domestic country.

Summarizing these findings into the next proposition:

Proposition 4.3: As ownership of the foreign firm increases in a managerial control setting, the welfare of both the foreign and domestic country most likely falls. This is due to the monopoly distortion caused by the movement of the domestic firm to a world multiplant monopoly.

Before leaving this section and concluding, revisit the welfare functions above with respect to the antitrust considerations. Some rather odd and difficult to explain conclusions were found. With respect to domestic welfare changes in (24), the only negative term is the first one, with the remaining four terms being positive. Thus domestic welfare likely increases with an increase in ownership, given that the ownership is a non-controlling interest. Prices are increasing, which harms consumers. However, the domestic firm is selling less in both markets. But at the same time, the domestic firm is receiving profit from its share of foreign activities.

The change in foreign welfare with a change in ownership in the China model is very difficult to explain. In (25), all terms will be negative, meaning that as the domestic firm increases its ownership in the foreign firm up to the maximum allowable level, foreign welfare unambiguously declines. Higher prices of output harm consumers once again, hence consumer utility falls. However, the foreign firm is selling more in both markets, facing less competition from the domestic firm.

4.5. Conclusion:

Horizontal integration, or mergers and acquisitions to use the business vernacular, have been widespread in the mid- to late-1990s. There is no evidence that this trend will subside in the near future. It has been shown that in an international duopoly framework, an acquiring firm should invest wholly into a competitor if those two firms are essentially identical.

In the third chapter of this dissertation, it was shown that in a Brander-Krugman world duopoly with an exogenous ownership variable, called β, horizontal acquisition may or may not be profitable. Given this problem, it was necessary to endogenize the ownership variable, which was done in this essay. Specifically, a one-shot two-stage game where two firms compete Cournot was assumed. In the first stage, the domestic firm chooses its optimal level of ownership of the foreign firm, and then competes Cournot with that firm in the second stage. Using backward induction, it was shown that the Cournot-Nash equilibrium that would result is one in which the domestic firm acquires managerial control and total ownership of the foreign firm $(\beta = 1)$. This level of ownership yields the highest total domestic profit. This result was illustrated in Figure 4.1. In the new equilibrium, the domestic firm increases its output in both markets, despite the presence of transportation costs. The foreign firm meanwhile decreases its total output, selling less in both markets.

In some cases, total ownership of the foreign firm may not be allowed. This possibility was discussed above. Total ownership of a competitor may not be allowed due to antitrust considerations. Alternatively, there may be a level of ownership in which attainment yields high (perhaps even prohibitive) protectionist pressures. As a result, the firm itself decides against absolute ownership. In either scenario, the domestic firm should acquire as much of its competitor as allowed. This is more profitable for the domestic firm than zero ownership.

With respect to national welfare, the results are not as clear. Foreign welfare likely falls with increased foreign investment by the domestic firm. National welfare changes from the standpoint of the domestic nation are somewhat less ambiguous. There is no clear end result, although it appears that domestic welfare falls with increased foreign asset acquisition by the domestic firm.

CHAPTER FIVE
VERTICAL INTEGRATION

5.1. Introduction:

This chapter views vertical integration from the standpoint of protection and foreign direct investment. It is concluded that market foreclosure in a three downstream, two upstream world will occur upon vertical integration by one of the downstream firms. Furthermore the integrated firm's dominant strategy will be to supply the input to competitors on the open market and assume the role of input price leader, which assists in leading the remaining downstream firms to consider countering with integration of their own. At input prices above the marginal cost of input production, counterintegration will not occur, and firms will proceed toward a collusive profit equilibrium. Specifically, a foreign firm will engage in protection-building trade, then vertically integrate with a supplier of key input to cause all firms to move toward a collusive equilibrium.

There are several reasons that international trade may occur between two nations. Climate, resource availability, and of course comparative advantage can each be a motive.[14] This essay considers the profit-maximizing anticompetitive strategy of a vertically integrated firm when one nation has the world market cornered with respect to resource availability. This chapter looks at a situation in which the contested market has a downstream firm, and two lone existing upstream firms. Additionally, two more countries are assumed, each housing a downstream firm that is competing with the firm in the contested market. This essay will illustrate two situations that may arise when a foreign downstream firm vertically integrates with an upstream firm in the domestic market. Price leadership is nothing new in oligopolistic models. However, price leadership tends to be written about in the context of final output, or downstream products. While approaching leadership from an upstream standpoint is not necessarily unique, it is not common in the literature in this situation of leadership after integration. The act of the vertically integrated firm operating with residual demand ultimately leads to higher input prices and restricted output than before integration. However, the newly

[14] Paul Krugman and Maurice Obstfeld, *International Economics: Theory and Policy 5th ed.*, (Addison Wesley Longman, 2000), 4,5.

integrated firm may very well decide to supply the input to competitors, but not necessarily obtain the inputs it receives at the marginal cost of input production.

Strategic vertical integration where there are no close substitutes to the input to production is very likely to increase input prices and lead to foreclosure. Two examples provided by the Federal Trade Commission are Time Warner with Turner Broadcasting and PacifiCorp and The Energy Group. The first deals with programming for distribution on cable television. Time Warner also has a stake in cable systems. To protect consumers from being adversely affected in either market, the FTC issued a consent order, prohibiting Time Warner from discriminating in either segment of the market, programming or cable systems. The second example deals with electric power. PacifiCorp is an electricity generating company in the western United States. This company wanted to purchase coal mines, which were significant inputs to production for electricity generating competitors.[15] This is the typical anticompetitive behavior that is investigated by the FTC with respect to vertical mergers.

The second alternative comes from the standpoint of the remaining unintegrated upstream supplier. It will be seen that this firm is the one that has a plethora of viable alternatives to consider. First of all if it decides to follow, this firm can basically act as a perfectly competitive firm, selling all it wants at the previously determined integrated input price. Conversely, this firm could attempt to integrate with one of the two remaining downstream firms. Lastly, if the integrated firm decides not to supply the input to competitors, then the unintegrated upstream firm can assume a monopoly position in the input market.

Game theory and integration have become widely researched avenues of international trade literature. Several papers have been devoted to identifying the effects of vertical mergers, and the impact they have on competition. Specifically, core papers in the field of vertical integration include Ordover, Saloner, and Salop (1990), where they present an equilibrium model of vertical integration, including rival behavior and counterstrategies, in which they find that vertical foreclosure can indeed emerge in equilibrium in a downstream and upstream duopoly framework. To the point, vertical

[15] Robert Pitofsky, "Statement of the Federal Trade Commission: Mergers and Corporate Consolidation in the New Economy," presented before the Committee on the Judiciary of the United States Senate, 16 June 1998, <http://www.ftc.gov/os/1998/9806/merger98.tes.htm>, (16 March 2002).

integration is a motive in achieving foreclosure of downstream firms from a source of key input supply, but only because an integrated firm obtains inputs at marginal cost.

With respect to situations in which both the upstream and downstream stages are oligopolistic and vertically integrated and unintegrated producers coexist, Salinger (1988) finds that a vertical merger may not necessarily lead to market foreclosure of unintegrated downstream firms. In his model, a vertical merger will lower the number of suppliers of the intermediate good, hence driving the intermediate good's price upward. However, the integrated firm produces more of the downstream product than the previously unintegrated downstream firm. The increase in final output causes the residual demand curve that the other remaining unintegrated downstream firms face to shift back, as well as the downstream firms' derived demand for the intermediate upstream good. With the assumption of linear demand curves, this causes a reduction in the price of the upstream good. If the effect on the derived demand curve outweighs the result of fewer suppliers in the upstream market, the intermediate good's price will fall. Thus when no foreclosure takes place, Salinger finds that a vertical merger unambiguously causes the price of the downstream good to fall.

Take note that other core works in vertical integration and anticompetitive behavior have been pursued in Salop and Scheffman (1983) and Hart and Tirole (1990). Other notable works in vertical integration include Riordan (1998), Lin (1988), and Spencer and Jones (1991). In fact, Spencer and Jones pursue vertical relationships with respect to international trading partners, and the optimal policy that may result.

Hamilton and Mqasqas (1997) devote attention to some flaws of previous work. Specifically, the aforementioned notion that vertically integrated firms always obtain the input at the marginal cost of input production. They find this assumption restrictive, and note that strategic internal transfer pricing may occur. This means that the manufacturing and retailing division are not necessarily combined. The two divisions are in fact related through integration, but internal transfer pricing helps to ensure that the upstream firm will relinquish control to the downstream firm. If an upstream firm knows up front that it will only receive an input price equal to the marginal cost of production, the downstream firm would have to provide a rather large lump sum payment to gain control of the upstream firm. In other words, the upstream firm may not have much incentive to give

up control. However, if the downstream firm increases the input price the upstream supplier would receive, this would benefit the upstream firm, making it more likely that it would relinquish control. This type of behavior is assumed in the model presented here, in that this appears to be a more realistic method of buying out an upstream supplier. This work goes beyond this normative analysis however. It will be shown below that when the downstream firm integrates and supplies the input to its competitors, the input price most definitely rises, without some explicit or implied promise to the upstream firm.

What is interesting in this chapter is that this problem is approached from the standpoint of strategic internal transfer pricing, much like Hamilton and Mqasqas. Not only will the input price for competitors increase, but also the integrated firm cannot obtain the input at marginal cost, which differs from Ordover, Saloner, and Salop's (OSS) previous work. Hence the integrated firm essentially pursues a policy that on the surface harms the downstream division.

Regarding trade, Bhagwati and Srinivasan (1976) were among the first to consider endogenous protection. Specifically, if an exporting nation realizes that its export volume may influence the likelihood of protection, then it should perhaps decide on an optimal trade policy. Standard endogenous protection theory suggests that increased export levels from a foreign country may lead to a higher probability of increased protection being levied against that country. Issues that emerged from this theory were foreign direct investment (FDI) and tariff-jumping. Bhagwati (1987) and Bhagwati et al. (1992) discuss quid pro quo FDI as a country's attempt to reduce the likelihood of protection being imposed, and hence prevent quantitative import restrictions.

On the other hand, tariff-induced FDI is when an import restriction such as a tariff or quota is exogenously given, and tariff-jumping investment occurs. This type of FDI is when a foreign country invests in the newly protected country and hence establishes a presence in that country, despite the already levied protection. Quid pro quo FDI coupled with a lower level of exports to a market lowers the probability of tariffs, yet allows the investing country to obtain a presence in the export market through its investment. Bhagwati (1987) further discusses FDI with respect to the ways in which it is perceived. He notes that FDI is used by lobbies on behalf of the exporting country in that it saves

jobs in the importing nation, while imports could possibly destroy jobs in that country. Bhagwati further states that unions are more and more considering FDI by a foreign exporter as a favorable alternative over protectionism.

Protection likely stems from lobbying by certain sectors in that country. Grossman and Helpman (1994) develop a model to capture this type of behavior. Specifically, they hypothesize that politicians set out to maximize their own welfare function, which comprises contributions collected by special interest groups lobbying for protection and the welfare of voters. These contributions of course are designed to influence policy. Grossman and Helpman (1996) further extend Bhagwati's work of quid pro quo foreign investment, and combine it with their earlier research on political welfare functions. They discuss the possibility of foreign investment and the opening of branch plants in a domestic nation by a multinational firm. They conclude that protection is a response by the incumbent government of the domestic nation, given campaign contributions by the firms located in that country.

With respect to empirical work in this field, Blonigen and Feenstra (1997) empirically pursue the hypotheses set forth concerning quid pro quo foreign direct investment. Using data on Japanese manufacturing FDI into the United States, they find support of the hypothesis that higher protectionist threats do indeed yield increased FDI. Furthermore, they find evidence that non-acquisition FDI (greenfield, or construction of a new plant) from Japan successfully defused protectionist threats, per quid pro quo theory. Lastly, Blonigen and Ohno (1998) pursue FDI and endogenous protection in an oligopolistic setting, and how this may result in a phenomenon they call *protection-building trade*. In this instance, with two foreign countries competing for the home market, one foreign firm actually increases exports to the home country in order to increase protection and hence have barriers levied on itself and its foreign rival in the future. The firm that purposely increases exports to the domestic nation is not harmed however, given that it opens a plant in the domestic market. This is not too dissimilar from work previously done by Anderson (1992) in which a firm, when faced with a positive probability of a voluntary export restraint (VER) being levied, strategically exports more to that market in an attempt to receive a greater share of the export licenses to capture rents that accompany VERs.

In the Blonigen-Ohno paper, their model of endogenous protection and FDI allows for three equilibria. The first possible equilibrium is the usual endogenous protection result. If faced with increased protectionist threats, all firms lower their exports to the home country. The second solution is the tariff-jumping result, in which both firms would locate to the home country in response to a protectionist threat. This allows both firms to avoid the tariff, choosing to produce locally over exporting. Producing locally would have a lower marginal cost. The third and final solution is the most interesting protection-building trade equilibrium, which is somewhat concerned with the firms' relative costs of FDI. Specifically, a firm engages in FDI only if the cost of doing so is less than the difference in profit from exporting with the tariff and producing locally (hence avoiding the tariff).

It is this last equilibrium solution that is of importance. In this chapter, it is assumed that a downstream firm vertically integrates with an upstream supplier. Before that integration, the downstream firm engages in protection-building trade behavior, increasing its exports to the nation in which the upstream suppliers are located. Upon incurring the tariffs from this nation, the downstream firm tariff jumps by merging with one of the two upstream suppliers. Notice the distinction between this essay and the Blonigen-Ohno work. First of all, this chapter is using FDI in the form of vertical integration. The Blonigen-Ohno paper can be thought of as a horizontal integration work if and only if the FDI is the act of buying out a plant in the target nation. If the FDI comes in the form of greenfield investment, which is the opening of a new plant in another nation, then this is not integration of any form. The act of buying out an existing firm may not come at a fixed cost. A firm's share price will be positively correlated with the increased purchasing of shares of ownership to acquire control. This presumably cannot be assumed away as a fixed cost for the most part. Regardless, the FDI comes at a different stage of the production process with respect to their work and this dissertation.

This chapter approaches the protection-building trade (PBT) result from the standpoint of tariff-jumping vertically, and not horizontally. The PBT outcome is a precondition to the model. When a nation imposes tariffs on imports from abroad, domestic production tends to increase with the increase in price that accompanies a tariff. The PBT behavior in the Blonigen-Ohno work allowed the tariff-jumping firm to gain a

cost advantage over its rival. The firm's cost advantage would presumably lead to higher profits. What is interesting in this work is that the PBT behavior, coupled with input price leadership, allows all downstream firms to move toward a collusive equilibrium in the face of higher input prices. This occurs in the absence of even tacit collusion on behalf of the downstream firms.

Secondly, and perhaps most importantly, it is interesting to note how U.S. antitrust policy relates to firm ownership. Historically, U.S. antitrust policy focuses much more on horizontal restraints than on vertical restraints to competition. When firms obtain more than three-fourths of a market, then the government will likely not permit a horizontal merger (deemed illegal per se). However, vertical restraints are subject to a rule of reason test. Notice that this is a more subjective type of analysis with respect to the impact on competition. Therefore, this vertical integration problem would likely be more acceptable from a practical point of view than a horizontal situation, as may occur under Blonigen and Ohno.

The model concerns price leadership in the input market. Again, this is not an obvious impediment to competition. Tacit behavior such as price leadership is difficult to prove, given that firms can change prices for a number of reasons, such as "changing economic conditions." It stands to reason that if one firm changes the price of its output, then a firm in a related industry may change the price of its output for the same reason, hence following suit. This work on vertical integration and tacit behavior is much more subtle and prone to more extensive government analysis than possible outright rejection.

Where much foreign direct investment theory is concerned with downstream firm construction or ownership, this chapter views this issue with respect to upstream firm ownership. In Section 5.2, the theoretical framework is formally presented. In Section 5.3, the model is solved through backward-induction to find any subgame-perfect equilibrium that results, while in Section 5.4 we seek robustness of the results by altering the model. Concluding remarks are provided in Section 5.5.

5.2. Basic Model Setup:

Suppose there is the following world: there exist three countries, which are labeled H (for the home country), F^A (for foreign country A), and F^B (for foreign country B). Assume a foreign duopoly, in which one firm, labeled DFA (Firm A), is the

downstream firm located in F^A, and the other firm is DFB (Firm B), the downstream firm located in F^B. Firm A exports x^A, while Firm B exports x^B to the home country. In the domestic country, there is a single domestic seller, DH (Firm H), which produces downstream good x^H for the home market. All three downstream firms produce the homogeneous product using the same key input, which they obtain from the upstream firms, U1 and U2, both located in the home market. The key input produced by U1 and U2 is homogeneous, and one unit of input produces one unit of the output, which is standard for all downstream firms. The foreign downstream firms then are dependent on the home market for the key input. They use this input in production of the downstream product, then sell these products back to the contested home market. The downstream firms all compete in Cournot, quantity-setting fashion; in other words, a case of strategic substitutes in the downstream product.

Assume prior to the game that Firm A, the downstream firm in F^A, has increased its exports to the home market to encourage protectionist pressures in that market. According to Cournot competition and endogenous protection, Firm B at this same time cuts its exports to the home country. The increased presence by Firm A in the output market in the home nation leads to protectionist lobbying by the downstream representatives in the home country, and hence tariffs to be levied to both foreign countries. This behavior is somewhat analogous to the aforementioned protection-building trade. Note that this assumption is not necessarily required for these results to hold. This is assumed at the outset of the game in that policy implications will be discussed later.

Given the levied tariff, Firm A then engages in anticipatory tariff-jumping, or foreign direct investment. Suppose however given the makeup of this world, Firm A chooses not to open a downstream plant in the home market, but to undergo backward vertical integration, merging with one of the upstream firms. One question is why would Firm A want to vertically-integrate, and not simply construct a downstream plant in the home country in order to avoid the tariff? Krugman and Obstfeld specify reasons such as supply disruption and conflicting profit maximizing goals of upstream and downstream firms. However, if the investing firm vertically-integrates, then it takes a chance in significantly affecting the profit of other firms through its manipulation of input supply.

Thus by vertically-integrating, it can vigorously compete by not *directly* adjusting the quantities available in the home market produced by Firm H and Firm B, but *indirectly* by either choosing or not to sell the input to these two downstream rivals. If the integrated Firm A chooses not to supply the input to its rivals, this would leave the two remaining downstream parties at the monopoly mercy of U2, raising their costs of production. Recall, the home downstream firm would wish to increase its production with the increased protection that it lobbied from the home government. But its desire to increase production will then be limited by facing a higher input cost.

The remaining questions are these which were first posed in the introduction: is the input price going to be higher after the integrated firm is formed, if that firm decides to supply the input? Would the integrated firm grant monopoly input-pricing power to the remaining supplier? Given that Firm A and U1 have integrated, will Firm H or Firm B attempt to vertically-integrate with the remaining upstream firm in the home market, and if so, who will succeed and who will be foreclosed from that market? What about an issue of input price leadership if the integrated firm supplies the input to competitors?

For the notation used here, Firm A will buy out and take over U1, and this merged firm is called M1. The two foreign firms are essentially identical at the outset: each one produces a homogeneous downstream product, with each firm incurring a tariff for exporting that product to the home market. Of course, any initial symmetry is lost with DFA's integration.

Stage 1: Firm A tariff-jumps by vertically integrating with U1. At this stage, the tariffs have already been levied. This stage specifically entails the vertical merger of Firm A with U1 to form M1. This investment on behalf of Firm A is called foreign direct investment (FDI), given the International Monetary Fund definition of FDI as "any ownership or interest by a resident from one country higher than 10% of the controlling shares in a company which is located in another country will be regarded as FDI, and it gives the rise to a MNE <multinational enterprise> (Tang, 1997)." The downstream firm in F^A has taken control of the upstream firm in the home market by owning a controlling interest, and has managerial decision-making ability of that firm. The vertically integrated firm is thus still exporting. It should be mentioned that no increase in

efficiency is assumed from vertical integration. In other words, Firm A does not enjoy any economies of scale from its behavior.

Stage 2: M1 makes its input availability decision to its rivals. For simplicity, M1 can do one of two things:

i) M1 decides to supply the input along with U2, or

ii) M1 does not supply Firm H or Firm B at all.

Stage 3: Firm B and Firm H may bid for the remaining supplier U2. It is possible that one of the other downstream firms could merge with U2 in response to the action that M1 takes in Stage 2.

Stage 4: Downstream firms play Cournot. According to OSS, the remaining unintegrated upstream and downstream firms will always counter a vertical merger with a merger of their own when the downstream firms compete in Cournot fashion. This is the stage where foreclosure from the home market will be analyzed.

5.3. Solving the Model:

In order to find the subgame-perfect equilibrium, it is necessary to solve this model using backward induction.

5.3.A. Stage 4:

Allow τ to be the per unit tariff imposed at the beginning of the game. The foreign downstream firms maximize profits, formally expressed for M1, as:

(1) $$\pi^M = p(X)x^M - c(w, x^M) - \tau x^M + w(X)[r^H(w) + r^B(w)] - m[r^H(w) + r^B(w)],$$

where: $p(X)$ = price of downstream output in the home market

$X = x^M + x^H + x^B$

τ = exogenous per-unit tariff

$c(..)$ = total cost function of producing x^M

m = marginal cost of producing the input

$r^i(w) = x^i(w) - S^i(w)$; where: $i = H, B$.

Take note of the expression r^i in the profit function above. This denotes a residual demand function. Given that $x^i(w)$ is the total downstream output produced by Firm H or Firm B (and consequently, the total input demand), then $S^i(w)$ is the input demand from U2. Hence, r^i is the input demand from M1 if that firm decides to supply the input

to production to downstream competitors. Therefore, the expression in (1) above is the case where both M1 and U2 are supplying the input to downstream competitors. Given that the foreign firm has not stopped exporting in this stage, it still incurs a tariff for exporting to the home market. The first three terms in (1) are the obvious total revenue net of total production costs for exporting. The latter two terms in the vertically integrated firm's profit function are the result of this firm supplying the input to its competitors at some price w.

Assume that transportation costs are negligible, and technically are a small fraction of the value of imported inputs and exported output. If we were to include some expression for transportation costs, it would be something along the lines of $\frac{t}{\lambda}$, where t would be the transportation cost per unit and λ would be a unit of output (or possibly a unit of input). By assumption then, cost per unit would be very small, approaching zero. Hence any term dealing with transportation costs, either in the importing or exporting stage, would fall out of the profit expression above. Thus transportation costs will not specifically be dealt with in this essay.

The question now is whether the input price is greater than or equal to the marginal cost of input production. It is shown below that upon vertical integration and input supply by M1, the input price will increase and hence be greater than the marginal cost of input production. At the beginning however, the input price, w, is equal to the marginal cost of input production. The reasoning is rather simple. If both *unintegrated* U1 and U2 had to simultaneously choose the input price, given the homogeneous input produced by both, they would both choose $w = m$. Without explicit collusion and given the initial symmetry of the upstream firms, there would be an incentive by each to continually undercut one another. Given that both firms would know this at the outset, each would charge the marginal cost in order to best avoid losses. This result is formally shown in Appendix A.

With the duopoly input price w in the cost function, this illustrates the situation of internal transfer pricing, where Hamilton and Mqasqas present a situation in which a firm manipulates input prices in an attempt to prevent counterintegration. This is also a real-world type phenomenon. In many instances when a firm takes over a supplier, that

firm typically pays some markup over marginal cost. This activity also encourages the downstream division of a vertically integrated firm to operate as efficiently as possible. The incentive for U1 to relinquish control of its firm will be greater if Firm A offers to set a higher input price.

The domestic downstream profit function is expressed as:

(2) $\pi^{H} = p(X)x^{H} - c(w, x^{H}) + j$ [int. profits]; j = 1 if Firm H counterintegrates
= 0 if not.

In Firm H's profit function, if j equals one, then the bracketed term will remain. These terms are to be interpreted in the same way as in (1). If j equals zero, then the domestic downstream firm's profit function is simply comprised of total revenue and total cost from producing and selling just the downstream product to the domestic market.

If a downstream competitor merges with the remaining input supplier U2, then the best responses come from the argmax of (1) and a similarly defined profit function. If it is Firm H, then it is the argmax of (2). Thus the solution would be $\{\hat{x}^{M}, \hat{x}^{i}\}$; i = H, B. These are the Cournot production levels: exports from M1, and home production from Firm H (or DH-U2 if merging), and exports from Country B, respectively. The derivation of the slopes of the best response functions of a representative downstream firm and the vertically integrated firm are presented in Appendix B.

5.3.B. Stage 3:

If Firm B does not merge, then its profit function is:

(3) $\pi^{B} = p(X)x^{B} - c(w, x^{B}) - \tau x^{B}$.

Firm B will want to merge if and only if:

$$\pi^{B}[c(w), (w-m)(r^{H})] - \pi^{B}[c(w)] > 0,$$

and will not make a bid for U2, which is denoted B^{B}, greater than this difference in profit from integrating and selling the input to Firm H, and not integrating. Similarly, Firm H will want to merge if and only if:

$$\pi^{H}[c(w), (w-m)(r^{B})] - \pi^{H}[c(w)] > 0,$$

and hence also will not make a bid B^{H} greater than this difference in profit.

Recall that in this stage, it is of importance to find out which remaining unintegrated downstream firm, if any, will win the bidding for U2 if it so chooses to engage. OSS approach this problem in the form of analyzing *stand-alone profits*, which are the sum of unintegrated downstream profits and an unintegrated upstream firm's profits. Looking at the remaining unintegrated upstream supplier after Firm A's initial integration, U2's profit function is:

$$\pi^{U2} = w(X)S^i(w^*) - mS^i(w^*) \text{; where } i = \text{H, B.}$$

Recall that S^i is the share of input sales that U2 receives from Firm H and Firm B. w^* is the input price that U2 accepts as a follower of the vertically integrated M1 if M1 supplies. Upon vertical integration taking place, M1 is a firm with considerable power. Given M1's presence in the home market in two forms, as an owner of key input supply and as a supplier of downstream output, M1 can influence how its competitors behave. Much integration literature deals with firms' ability to commit to upstream prices. Even with no explicit collusion, a commonly accepted model of oligopoly is price leadership. With M1's new makeup as a vertically integrated firm, it would not be unreasonable to think that U2 would look to M1 for leadership. If M1 assumes an input price leadership role, U2 would then take this input price as given, and sell all it wants at that price.

The obvious question is why would U2 want to follow? Recall that prior to the game, if there were no integration, it would be selling the input at marginal cost along with U1. If M1 assumes a leadership role, an increase in input price benefits U2. This comes from the fact that U2 behaves as a perfect competitor when following. As a follower, any increase in its input price above that of M1's causes U2 to sell nothing, while any decrease would not be efficient, given that U2 can sell as much as it wants at the going input price set by M1. This is revisited in the next stage.

Intuitively, U2 will sell control of its firm if the bid it receives is higher than the profit it could make by either, a) charging the monopoly input price to Firm B and Firm H, or b) charging the duopoly input price w^*, which prevails when M1 supplies the input to competitors and acts as input price leader.

If a bid is to be made, the problem then is which downstream firm will make the higher bid. Quite obviously, all other things equal, U2 will take the highest bid. Remember that the bid will be no larger than the difference in downstream firm profit

from integrating and not integrating. If U2 so decides to integrate, it will sell its ownership and control unambiguously to Firm H because it will always offer the higher bid. Firm H and Firm B would both face the same input price determined in Stage 2, thus this provides the basis for the downstream firms in deciding whether or not to merge in Stage 3. Even though Firm H has already used resources in lobbying the home government for protection, these are sunk costs and are irrelevant to the firm's current decision-making. To see why Firm H would win the bidding for U2, note that:

$$\pi^{B}[c(w,\tau),\text{int. profits}]-\pi^{B}[c(w,\tau)]<\pi^{H}[c(w),\text{int. profits}]-\pi^{H}[c(w)]\text{, hence,}$$

$$B^{B}<B^{H}.$$

The bid from Firm B will *always* be smaller than that of Firm H, given the presence of tariffs in Firm B's profit function. Tariff imposition causes Firm B's profit to fall, since $\frac{\partial\pi^{B}}{\partial\tau}<0$.

Given that Firm H will always win, it is necessary to analyze whether U2 would be willing to relinquish managerial control of its firm and integrate with Firm H. This answer is fairly straightforward in any assertion of price leadership. If U2 follows M1's lead, then U2 can sell all the inputs it wants at the input price that M1 sets. There is no need for U2 to undercut M1 if it takes that price as given. Furthermore, U2 and M1 are not symmetrical firms. U2 is an input-producing firm, while M1 is a vertically integrated firm. U2 will choose to follow if M1 prefers to lead. Dowrick (1986) proposes that given downward sloping (or upward sloping) reaction functions, if one firm takes the lead, the other firm prefers to follow. This holds provided that there is no capacity constraint and that the firms are not symmetrical.

But one can go beyond this normative conclusion. In fact, it is necessary. As noted above, OSS present counterintegration decisions through its analysis of stand-alone profits. Specifically, OSS observe the changes in stand-alone profits with a given change in input prices. Using this framework, the stand-alone profits would be presented as follows:

$$\pi^{U+D}=w(X)S^{i}(w)-mS^{i}(w)+p(X)x^{H}-c(w,x^{H}).$$

Differentiating the expression for stand-alone profits with respect to the input price yields:

(4) $$\frac{\partial \pi^{U+D}}{\partial w} = \frac{\partial S^i}{\partial w}(w-m) - c_w + S^i(w) + p'(X)x^H \frac{\partial X}{\partial w} + \frac{\partial x^H}{\partial w}(p(X)-c_x).$$

If this expression were evaluated when the input price equals the marginal cost of input production, the first term in (4) drops out. Additionally, assuming that the downstream firm operates at the optimal level of output expressed by its first-order condition, this leaves:

(5) $$\frac{\partial \pi^{U+D}}{\partial w} = -c_w + S^i(m) + p'(X)x^H [\frac{\partial X}{\partial w} - \frac{\partial x^H}{\partial w}].$$

Since an increase in input prices will increase total costs, the first expression in (5) is negative. The latter two terms are positive. Admittedly, signing this expression is still not straightforward. But it appears there are output and input levels high enough to outweigh any negativity in (5). These high levels of course would be due to low input prices. If (5) is positive at this low input price (in this case, zero economic profit conditions for the upstream firms), then small increases above marginal cost will yield increases in the stand-alone profits. This would provide an incentive for U2 and Firm H to remain apart. If input prices increase and then stand-alone profits increase, U2 and Firm H enjoy higher profits by staying apart. This conclusion falls in line with that reached by OSS.

Why might the input price increase? It is shown in the next stage that if M1 supplies, the input price indeed increases. Let us now revisit expression (4). As the input price significantly rises above the marginal cost of input production, then the term $\frac{\partial S^i}{\partial w}(w-m)$ reappears as in (4). This term is negative, and hence will lower π_w^{U+D}, in fact making it negative. As a result, a motive for counterintegration would be present. U2 and Firm H would not do better individually.

In concluding this stage then, the following proposition is presented:

Proposition 5.1: If M1 supplies the input in the open market and assumes an input price leadership role with U2 following, then U2 does not integrate with Firm H at low input prices (although still above marginal cost). If M1 does not supply the input, U2 assumes a monopoly position in the input market, again not counterintegrating.

Notice the last part of Proposition 5.1. Recall what happens if M1 does not supply. U2 would have a monopoly in the input market, increasing its input price to w^m, which is of course above marginal cost, m. This is revisited in Stage 2. Using conclusions reached by OSS and also shown here in this subsection, high input prices promote counterintegration. This is due to stand-alone profits falling with very high input prices. Therefore it is necessary to set out and prove this part of Proposition 5.1.

5.3.C. Stage 2:

In this stage, input decisions are considered. OSS actually presented three cases: a situation where both an integrated firm (M1) and an unintegrated supplier simultaneously decide the input price to charge the unintegrated downstream firm, a situation where M1 decides not to supply, and lastly, a case in which M1 acts as first-mover. In a reply to Reiffen (1992), OSS (1992) admit that they implicitly introduced dynamic concepts into the input-pricing stage of their original work. They claim that upstream prices may indeed not be set in an instant, but that they may be negotiated dynamically by the unintegrated downstream firm and the input suppliers. For any given price that U2 would charge Firm H and Firm B, M1 has an incentive to undercut that input price, and this undercutting would continue until input prices would be competed toward the marginal cost of input production, provided there exists no collusion between M1 and U2. Given this postulate, the incentive of vertically integrating to engage in anticompetitive behavior against downstream rivals is lost.

Where OSS potentially go wrong is in their assumption of M1 acting as first-mover. They stipulate that M1 would manipulate input prices to an extent that would prevent a countermerger by the remaining unintegrated supplier and downstream firm. They state that M1 would obtain the input at marginal cost, while the remaining unintegrated downstream firm would be charged a higher input price. While they consider precommitment of the input price prior to U2's input pricing decision, they incorrectly assume M1 receives the input at marginal cost. In fact, Bork (1978) explains that a firm obtaining its inputs at production cost while competitors pay a higher market price simply will not occur.[16] This problem is corrected in Hamilton and Mqasqas, where they conclude that an integrated firm will supply nonintegrated competitors and the firm

[16] Bork, 228.

itself at an input price above marginal cost. In their open market trading strategy, the integrated firm employs the quantity of the intermediate good and sets the transfer price, w, to maximize profits. This chapter follows that procedure, along with the model of price leadership, in evaluating Firm A's response to the tariff imposition.

Consider two broad cases. In case i), M1 and U2 both choose to supply the input to the two remaining unintegrated downstream firms, Firm H and Firm B. With respect to case ii), M1 chooses not to supply the downstream firms at all. In this instance, U2 will obviously charge the monopoly input price, w^m, and hence earns the monopoly profit from being the sole input supplier to Firm H and Firm B. Salop and Scheffman (1983) explain that firms could act strategically in competition with other firms by attempting to raise those rivals' costs. The motive of this action is to cause the rival firms to reduce their output, while the other firm steps in and increases production to compensate.

If M1 takes the lead, it is necessary to find out what the optimal input price will be. If M1 supplies the input, then it will choose the input price which maximizes its integrated profits. Thus, differentiate (1) with respect to input price and find:

$$\frac{\partial \pi^M}{\partial w} = p'(X)x^M \frac{\partial X}{\partial w} + [p(X) - c_x - \tau]\frac{\partial x^M}{\partial w} + r^H(w) + r^B(w) + (w - m)(\frac{\partial r^H}{\partial w} + \frac{\partial r^B}{\partial w}) - c_w.$$

Setting this expression equal to zero, and solving for w leads to:

$$w^* = \frac{-\frac{\partial X}{\partial w}p'(X)x^M - [p(X) - c_x - \tau]\frac{\partial x^M}{\partial w} - r^H(w) - r^B(w) + m(\frac{\partial r^H}{\partial w} + \frac{\partial r^B}{\partial w}) + c_w}{(\frac{\partial r^H}{\partial w} + \frac{\partial r^B}{\partial w})}.$$

For a sensible input price, w^* must be positive, which requires that:

$$[-r^H(w) - r^B(w) - \frac{\partial X}{\partial w}(p'(X)x^M) + m(\frac{\partial r^H}{\partial w} + \frac{\partial r^B}{\partial w})] > [-\frac{\partial x^M}{\partial w}(p(X) - c_x - \tau) + c_w]$$

at the optimal price that maximizes integrated M1's profits.

Is this price greater than marginal cost? Subtracting m from this w^*:

$$(w^* - m) = \frac{-\frac{\partial X}{\partial w} p'(X)x^M - [p(X) - c_x - \tau]\frac{\partial x^M}{\partial w} - r^H - r^B + c_w}{(\frac{\partial r^H}{\partial w} + \frac{\partial r^B}{\partial w})}.$$

For a sensible input price, the numerator must be negative, which means that:

$$[-r^H(w) - r^B(w) - \frac{\partial X}{\partial w}(p'(X)x^M)] > [-\frac{\partial x^M}{\partial w}(p(X) - c_x - \tau) + c_w].$$

High values of r^H and r^B, as well as x^M ensure that this is so. Of course, higher values of these variables correspond with low input prices. This input price maximizes the integrated firm's total downstream and upstream profits, and U2 will follow this price. However, the input price is not so high that it encourages U2 and DH to counterintegrate (recall the stand-alone discussion above).

OSS discussed setting the input price at such a level as to forestall counterintegration. They basically dealt with the integrated firm trying to take market power away from U2. In this case, U2 is M1's ally. Everyone is increasing the input price on the open market. But M1 will most definitely not allow U2 to have too much freedom.

With respect to this stage, it is helpful to illustrate M1's situation by using best response functions. Taking the first-order condition of (1):

$$\frac{\partial \pi^M}{\partial x^M} = p'(X)x^M + p(X) - c_x(w, x^M) - \tau + w'(X)[r^H(w) + r^B(w)] = 0.$$

In deriving the effects on M1's best response function with a change in input price, define M1 exports as $x^M = \phi(x^H, w)$. This allows:

$$(6) \qquad \frac{\partial x^M}{\partial w} = \frac{\partial \phi}{\partial w} = -\frac{\frac{\partial^2 \pi^M}{\partial x^M \partial w}}{\frac{\partial^2 \pi^M}{\partial x^{M^2}}}.$$

In (6), the denominator is negative by the second-order condition for profit maximization.

Accordingly, the sign of (6) will be the sign of $\frac{\partial^2 \pi^M}{\partial x^M \partial w}$. Given the definition of x^M, it is necessary to find the change in this variable given x^H. This leads to

$\frac{\partial^2 \pi^M}{\partial x^M \partial w} = -c_{xw} < 0$. An increase in input prices will increase marginal cost, leading this partial second derivative to be negative. Therefore, M1's best response function shifts in with an increase in input price at every level of x^H. This means that exports from M1 will fall with an increase in input price at any given x^H.

Turning now to Firm H's best response, take the first-order condition of its profit function *with no integration profits*. This is per Proposition 5.1. Formally,

$$\frac{\partial \pi^H}{\partial x^H} = p'(X)x^H + p(X) - c_x(w, x^H) = 0.$$

As above, define domestic downstream output now as $x^H = \psi(x^M, w)$. A change in x^H with respect to a change in input price would be expressed as:

$$(7) \qquad \frac{\partial x^H}{\partial w} = \frac{\partial \psi}{\partial w} = -\frac{\frac{\partial^2 \pi^H}{\partial x^H \partial w}}{\frac{\partial^2 \pi^H}{\partial x^{H^2}}}.$$

As before, given the negativity of the second-order condition for profit maximization in the denominator of (7), the sign of $\frac{\partial \psi}{\partial w}$ equals the sign of $\frac{\partial^2 \pi^H}{\partial x^H \partial w}$. Evaluating the latter it is seen, as above, $\frac{\partial^2 \pi^H}{\partial x^H \partial w} = -c_{xw} < 0$, and again with an increase in input price, Firm H's best response function shifts in at every x^M. Therefore, domestic downstream output falls with an increase in input prices at any given x^M.

Notice that these two impacts on the firms' best response functions are essentially the same in magnitude, and exactly the same in effect. In Figure 5.1, both of these effects are placed together on the same diagram.

Notice the equilibrium that emerges. If M1 supplies the input and assumes price leadership in the input market, the input price increases. But notice the odd result seen in the diagram. The activity of M1 increasing the input price to both Firm H *and itself* causes the two firms to move toward a collusive equilibrium, and for *both* firms to operate on a higher isoprofit curve. Thus, M1 does not use U2 as an ally in "raising

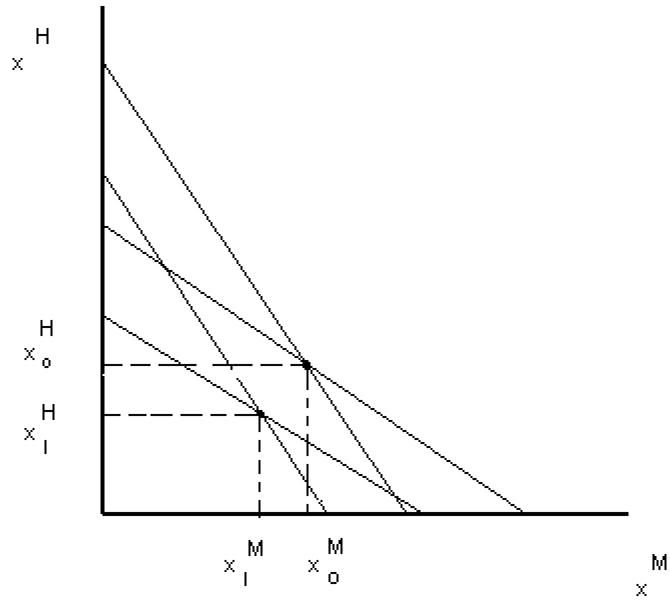

Figure 5.1—M1 Supplies

rivals' costs," in the general sense that M1 does not attempt to foreclose Firm H and then increase exports to that market to compensate. M1 chooses to foreclose *itself* as well as its rivals.

What about the presence of Firm B? Protection-building trade causes tariffs to be levied on both Firms A and B. Thus, Firm B's presence in the home market is lessened by this action. Additionally, Firm B would not win in the bidding for U2 even if U2 saw fit to integrate. Firm B faces the same higher input price that both M1 and Firm H encounter, which also causes it to lower its exports to the home market. Most certainly, there is not much difference between the downstream division of M1 and Firm B. In fact, there is not any difference since the exports from both firms are tariffed. But recall the key difference between these two firms. M1 has an upstream division, whose profits are part of the total profit of the integrated firm. The higher input prices benefit the upstream division, hence benefiting the entire integrated firm. Firm B of course does not have this luxury, and thus is not as better off as M1, nor even Firm H (whose output is not tariffed since that firm is located in the contested market).

In concluding the discussion of this stage, consider the second option M1 has. Perhaps it will not supply the input to competitors at all, granting U2 monopoly input-pricing power. Some of the vertical integration literature contends that an integrated firm would receive the input at marginal cost. It was mentioned above that this is a bold and rather incorrect supposition. If M1 does not supply but engages in strategic internal transfer pricing, then the best response functions look much like Figure 5.1, with the exception that Firm H's will shift in further than M1's (see Figure 5.2 below). U2 will charge w^m to both Firm H and Firm B, while the upstream division of M1 charges some lower input price $w^u > m$, set by M1. Thus, there will be an equilibrium that puts M1 on

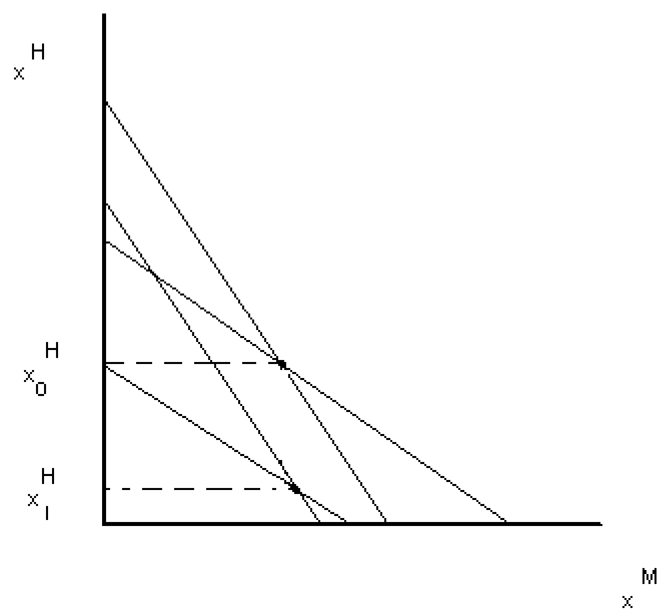

Figure 5.2—M1 Does Not Supply

a higher isoprofit curve, but not necessarily Firm H. This would provide Firm H an incentive to counterintegrate. If this were to occur, M1 would not be on as high an isoprofit curve. Therefore, M1 should supply the input and lead, and incur additional profits from the upstream division. This ends up benefiting Firm H as well, which is

completely the opposite to any intuition supported by advocates of "raising rivals' costs" behavior.

Summarizing these findings into the second proposition:

<u>Proposition 5.2</u>: If M1 supplies the input to competitors in the open market, strategic internal transfer pricing causes both Firm H and M1 to approach a collusive equilibrium in their competition for the home market. This equilibrium results in the *absence* of explicit or tacit collusion among the downstream firms.

What is interesting about all this is that M1 wants to forestall integration so that it can attain its highest isoprofit curve, even if this comes at the expense of yielding some market share and profit to Firm H in an attempt to appease that firm. Thus M1 supplying the input and leading U2 in the input market appears to be a dominant strategy.

5.3.D. Stage 1:

In this stage, Firm A tariff-jumps by vertically integrating with U1. Recall that the tariff has already been imposed upon Firm H's foreign downstream rivals. In response to this tariff, Firm A engages in FDI by taking over an upstream firm, and takes command of that upstream firm's decision-making. It is assumed that Firm A incurs a fixed cost, k^A, of vertically integrating with U1 (a lump sum payment). It should be noted that Firm A will only undergo backward vertical integration if this k^A is less than the difference in firm profit from exporting after vertically-integrating, and simply exporting. In other words, Firm A will vertically-integrate if and only if the following condition holds:

$$k^A < \pi^M(x^M, w) - \pi^A(x^A, m).$$

Firm A's profit maximization problem in this stage is expressed simply as:

$$\pi^A = p(X)x^A - c(m, x^A) - \tau x^A. \qquad (8)$$

The reader can think of k^A as a type of cost-benefit or net present value analysis. Firm A will undergo this analysis prior to its decision. If by maximizing the present value of future cash flows, the fixed cost of integration is greater than the difference in profit flows from integration and simply exporting, then this sequential stage game does not begin in the first place. Therefore, it is assumed that the condition holds, Firm A vertically-integrates with U1, and establishes an upstream presence in the home market.

Of course, just as before in Stage 3, an upstream firm will not sell off control of its firm if $k^A < \pi^{U1}[x^i, m]$; where i = A, B, H.

Since k^A is essentially Firm A's bid for U1, if $k^A = \pi^{U1}[x^i, m]$, then U1 is indifferent to relinquishing managerial control of its firm to Firm A. The obvious question is what can drive this bid to a point where U1 would sell off control? U1 has to be enticed to give up control of its firm. If M1 promises a higher input price to U1 upon integration, then this would push the price above marginal cost. Thus U1 would be more likely to sell. This is admittedly somewhat normative. But U1 would jump at the chance of integrating if M1 promised to raise the input price. As has been illustrated above, the strategy that occurs is M1 in a leadership role with higher input prices, allowing everyone to benefit. Therefore, U1 sells to Firm A and M1 is indeed created as a response to tariff imposition.

5.3.E. Subgame-Perfect Equilibrium Summarized:

Given that each stage of the game has been detailed in this section, it is perhaps necessary to simply summarize the subgame-perfect equilibrium that arises. In Stage 4, the downstream firms play Cournot, and the intersection of the best-response functions detail the Nash equilibrium. The downstream firms are all foreclosed, including the integrated firm. Each firm moves more toward a collusive equilibrium, with each one operating on a higher isoprofit curve. Given the explanation of Stage 3, in which Firm B and Firm H bid for the remaining unintegrated supplier, Firm H would ordinarily win any bidding situation that develops for U2. Recall that it bases its merging decision and hence its possible bid for U2 on the input price that arises from either U2 alone, or U2 and M1 together.

If M1 supplies and takes the lead in the input market, it chooses the input price that maximizes integrated profits. This w^* is greater than the marginal cost of input production, m. U2, which was once charging the marginal cost, now will find it beneficial to follow M1. Remember that if M1 prefers to lead, then U2 prefers to follow. Strategic internal transfer pricing mandates that M1 also pay this higher price, and not receive the input at marginal cost.

Will U2 counterintegrate? If the input price rises too much, then it is highly likely given the analysis of stand-alone profits completed earlier. Therefore, M1 will most

certainly supply and dilute U2's market power as to prevent counterintegration and potentially suffer a decrease in profit from that action by Firm H. Thus it appears that all firms move toward the collusive equilibrium as long as M1 supplies and U2 follows.

Firm B potentially benefits and moves toward the collusive equilibrium as well, but it has neither an upstream division like M1, nor the luxury of tariff-free exports to the contested home market.

5.4. Robustness and Contesting Markets Elsewhere:

In this section, a few brief comments are made concerning the location of the contested market. In other words, what if the three downstream firms in this model are not competing for the home market, but for foreign country B, where Firm B is located? Any significant volume of imports flowing into that nation could possibly lead to increased protection. As above, suppose that Firm A initiates and merges with U1, forming M1. Strategic internal transfer pricing or price leadership forces the input price to rise. Any bidding for U2 would this time be won by Firm B, since it would be Firm H's exports that would be tariffed. With the same intuition applied before, U2 would really find no incentive to sell control at low input prices, although still above marginal cost. Best response functions would shift inward, and all firms would move closer to a collusive equilibrium.

If the contested market is foreign country A, the end results are seemingly just as clear. If Firm A is again the initiator and merges with U1, a tariffed Firm H and Firm B would not be able to offer starkly different bids to capture U2. If again U2 does not decide to integrate however, any price leadership or internal transfer pricing causes the best response functions of all firms to shift in toward their collusive equilibrium once again. Therefore no matter where the contested market is, the effects in this model are essentially the same.

Additionally, what if the home market was not the sole location of the upstream firms? What if they were located in country B? Again, nothing significantly changes the Nash equilibrium. The reason for this has nothing to do with firm location, but with the effect on input prices. As long as they increase, especially not to extremely high levels, there will be no counterintegration. Thus the results remain the same: movement toward collusive profits without explicit collusive behavior among downstream firms.

Summarizing this conclusion in the final proposition for this chapter:

<u>Proposition 5.3</u>: Regardless of the location of the upstream firms or the contested market, as long as integration raises the input prices slightly but not significantly above marginal cost, then all downstream firms move toward a collusive equilibrium despite the absence of collusion among the downstream firms.

5.5. Conclusion:

In a world where the home market is the sole location of the key input, a foreign downstream firm has an incentive to undergo backward vertical integration in response to a tariff levied by an importing country. In pursuing this strategy, the integrated firm does not avoid the tariff, whereas it would if it pursued greenfield investment. However, upon vertically integrating with an input supplier, the merged firm can further influence what happens to the profitability of its competitors. This tariff-jumping through vertical integration on behalf of the foreign downstream firm allows that firm to establish a presence in the home market, and forces the remaining downstream firms to make a decision of vertically-integrating or not with the remaining upstream supplier. It was discovered that no matter if M1 restricted supply of the input or not on the open market, input prices tend to rise.

With respect to possible counterintegration by either Firm H or Firm B, Firm H would unambiguously win the bidding for the remaining upstream firm, U2. This is due to the fact that Firm H's profit should be higher because of tariffs incurred by Firm B. However, this is a rather moot point given that U2 does not find it profitable to sell off control of its firm to Firm H, especially at input prices slightly above marginal cost.

An integrated firm that assumes a price leadership role increases the input price above marginal cost, with the remaining unintegrated firm following suit. This produces a somewhat paradoxical result in that the best response functions of both firms producing a downstream product will shift inward. The counterintuitive result is that because of strategic internal transfer pricing, M1 doesn't simply raise rivals' costs to force them to reduce output, wherein M1 will then step in and compensate. Instead M1 *also* incurs a higher input price, either through taking the lead and setting an input price that maximizes total integrated profits, or yielding the open market to U2, allowing it to charge a monopoly input price. Despite the fact that these input-producing firms, if

having to set prices in an instant, sell the input for marginal cost, M1 will probably not enjoy this luxury after integration. An incentive for U1 to sell control would be the promise of a higher input price to the upstream division. This would undoubtedly occur if M1 maximizes its profits with respect to input prices, in hopes of deriving the optimal input price for its upstream division to charge not only to the downstream division of M1, but also to competitors.

Obviously, several questions abound with respect to this type of analysis, but the key result is that when a downstream firm faces a tariff, the optimal response is to vertically-integrate with a supplier, given the impact of input prices on downstream best response functions. Notice that integration does not simply "raise rivals' costs" as in previous research. The integrated firm incurs higher costs as well through internal transfer pricing in order to increase integrated profits, provided U2 follows suit. Higher output prices which result from higher input prices would tend to cause firm profits to rise if the price effect outweighs any reduction in downstream quantity demanded. This is apparently what transpires. As illustrated in Figure 5.1, best response functions of downstream firms shift inward. Since both shift inward, the firms are moving in the direction of a collusive equilibrium, even though production costs increase.

Foreclosure is a topic often associated with vertical integration papers. That was not so much the focus here, but it is apparent that some degree of foreclosure exists among all firms. Not only will unintegrated downstream firms see reductions in output to the contested market, but so will also the integrated firm.

In conclusion then, FDI (tariff-jumping) in the form of vertical integration may result in anticompetitive behavior through foreclosure. But in tapping a related market and hence controlling the key input available to competitors, all downstream firms are actually made better off than before, at the expense of domestic consumers. Given protection-building trade, a domestic firm would want to increase its output after its government levies protection. With backward vertical integration however, the integrated firm potentially controls a significant portion of the input market, preventing the domestic firm from increasing its output in the presence of higher input costs. The vertically integrated firm captures input market share if it supplies to competitors. These gains outweigh the negative effects of lower quantities consumed in the domestic market.

CHAPTER SIX
BAYESIAN FORECASTING

6.1. Introduction:

Cost functions lie at the heart of basic economic theory. The properties of these functions are taken as given in theoretical work. Theory implies that cost functions satisfy the properties of monotonicity, concavity, and homogeneity. Modern econometric tools provide a means to impose these conditions in empirical studies. However, a close look at the empirical literature reveals that few studies impose these conditions and that many estimated cost functions violate monotonicity and concavity properties. Using data from electric utilities, this study compares the forecasting accuracy of the translog with and without theoretic restrictions imposed. Such a comparison will assist in answering a fundamental question of whether theory matters in empirical work. The estimates will also provide further insight into the cost structure of electric power generation as the industry continues down an uncertain road to privatization.

Empirical applications using cost functions begin by choosing a functional form. Over time, economists have used more and more complex functional forms. Initially, the Cobb-Douglas (1928) function was widely used, given its simplicity. However, the Cobb-Douglas function is rather restrictive (i.e., inflexible), in that it assumes constant shares of inputs, and input price elasticities of unity.

By "flexible," it is meant the degree to which a functional form fits the data. In the empirical literature, those who do not impose regularity conditions sometimes attempt to "overfit" an equation to the data. In so doing, economists sometimes arrive at a functional form in which the estimated input shares violate economic theory. To be more specific, overfitted regressions may result in input demand functions that do not obey the law of demand. Therein lies the quest for a flexible form that estimates a cost function in accordance with economic theory.

As an alternative to the inflexibility of the Cobb-Douglas, the constant elasticity of substitution (CES) functional form was developed by Arrow, Chenery, Minhas, and Solow (1961).[17] The proposed CES technology is much more flexible than the Cobb-

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[17] Work concerning the elasticity of substitution began with J. Hicks, *Theory of Wages*, (London: Macmillan, 1932).

Douglas due to the fact that this functional form may take a variety of other forms depending on the value of the exponent parameter, ρ. Differing values of this parameter describe how substitutable inputs to production can be. The Cobb-Douglas is but one of these possibilities. However, the CES technology is still restricted, forcing all elasticities of substitution to be equal to ρ, or –1.

Later, researchers moved to the use of the transcendental logarithmic production frontier (the translog) functional form, put forth by Christensen, Jorgenson, and Lau (1973). This functional form was supported empirically, with tests falling in line with production theory. Their empirical tests of the CES production function revealed that this functional form was inappropriate in the presence of several outputs and several inputs; hence their movement toward the translog. The translog satisfies Diewert's (1974) definition of a flexible functional form.[18] Additional functional forms researched beyond the translog have been the Fourier (Gallant, 1981) and the Asymptotically Ideal Model (AIM) (Barnett and Yue, 1988). However, neither the Fourier nor the AIM has garnered nearly the level of acceptance as the translog. This lack of acceptance stems from the complexity of these two functional forms.

Wales (1977) uses a Monte Carlo study to investigate the ability to approximate constant elasticity of substitution utility functions with two goods. One goal of his work is to find if the regularity conditions, those being quasiconcavity and monotonicity, are satisfied with different functional forms. Wales finds that the two flexible forms (the translog and the generalized Leontief) yield a good local approximation (at the mean values of each good) while not always providing a good approximation over a range of observations. This approximation is measured by the ability of the flexible forms in satisfying conditions needed for utility maximization, such as the existence of a positive estimated elasticity of substitution between two goods for the property of quasiconcavity. Despite the violation of regularity conditions in empirical work, Wales specifically states that these violations do not prevent a researcher from obtaining good estimates of price and income elasticities. It is interesting to note, however, that the same work footnotes

[18] Specifically, Diewert defines a flexible functional form as a function that yields a second order differential approximation to any cost function that is twice differentiable, and satisfies linear homogeneity at any price.

the fact that in this situation it would be impossible to find whether these estimates were close to the true values.

Given the violations of theoretical properties in translog applications, Jorgenson and Fraumeni (1981) propose using the Cholesky factorization approach to impose concavity on the translog. With the imposition of concavity restrictions, Jorgenson and Fraumeni find that estimates are indeed more precise, as long as input share is nonincreasing in own-input price.

It is important at this point to make a distinction between local and global concavity. Given that concavity is the property of conditional inputs obeying the law of demand, *global* concavity occurs at all positive input prices. *Local* concavity implies that this property holds at a single price, and not at all positive input prices.

Given this empirical evidence, the literature then turned to the idea of imposing certain conditions on flexible forms to satisfy the regularity conditions of cost functions. This idea has not come without controversy, principally because some researchers feel that imposing conditions restricts the flexibility of functional forms. This concern is certainly prevalent when the issue is imposing conditions globally rather than locally. With restrictions of global concavity, estimates of various elasticities are adversely affected. Global concavity implies that the impact of price on input use will have a negative relationship at all positive prices. The imposition of constraints and their subsequent effects on flexibility has been shown by Lau (1978), Jorgensen and Fraumeni (1981), and Diewert and Wales (1987).

Specifically, Diewert and Wales (1987) show that imposing concavity and monotonicity globally restricts flexibility of the translog. Given that concavity tends to be violated more than monotonicity, the notion has been to impose restrictions that satisfy global concavity but not monotonicity. But even these restrictions remove the flexibility of previously used flexible forms, making them "semiflexible." Diewert and Wales find that the constraints imposed by Jorgenson and Fraumeni bias own-price elasticities toward one. Additionally, for inputs with small shares, the constraints bias cross-price elasticities to zero.

Gagne and Ouellette (1998) pursue Monte Carlo tests on the translog, the symmetric McFadden, and the symmetric generalized Barnett. Their results indicated to

them that the imposition of global concavity was inadvisable. Convergence was not achieved in over a third of the cases they investigated. When Gagne and Ouellette imposed curvature properties on functional forms, monotonicity was rejected much of the time. They found that when curvature conditions were not imposed, results were considerably much improved. Terrell (1995) also found that imposing global concavity on the Asymptotically Ideal Model (AIM) restricts the flexibility of that model. Gagne and Ouellette use this conclusion, along with their own investigation, to conclude that global imposition of concavity is a mistake.

Clearly, a functional form satisfying global concavity would be ideal. Despite the best efforts of prior research however, global concavity remains elusive in empirical work. Further attempts at obtaining a functional form in which global concavity is satisfied usually result in functional forms that are increasingly complex.[19]

In response, the literature has turned to the imposition of local concavity. Imposition of local concavity is defined as constraining a single input price, multiple input price combinations, or a range of input prices, to obey economic theory. It follows that by guaranteeing concavity at one data point, other points in a surrounding region may also satisfy concavity if that reference point is a "judicious choice."[20] In fact, Ryan and Wales (1998, 2000) find that imposing concavity at the mean yields satisfaction of concavity at all points in their data set (1947-1971 data on output of U.S. manufacturing industries, using four inputs: capital, labor, energy, and materials). The primary advantage of imposing concavity locally rather than globally is that functional forms tend to retain their flexibility in the presence of local constraints.

Given these positive findings regarding the imposition of local concavity, a significant number of researchers have pursued empirical work along these lines. Among those in favor of imposing conditions are Pitt and Millimet (2000), who impose the necessary conditions for coherency (probabilities of demand regimes summing to one) locally at each data point using Gibbs sampling and rejection sampling. In so doing, they use simulated demand systems from the translog utility function and household

[19] In fact, Tishler and Lipovetsky (1996) attempt to develop a cost function which is not only flexible, but also globally concave and monotonic.
[20] David Ryan and Terence Wales, "Imposing Local Concavity in the Translog and Generalized Leontief Cost Functions," *Economics Letters*, 2000, 67:3, 254.

expenditure data from Indonesia. They find that imposing local coherency is better than imposing global coherency, in that the acceptable parameter space is significantly restricted upon the imposition of global coherency conditions. Therein lies another reason for the imposition of local versus global constraints.

Terrell (1996) goes beyond the practice of imposing regularity conditions on individual points by imposing the conditions over *ranges* of points, such as prices. He avoids the problem of global approximations mentioned above by using a flexible functional form as a local approximation of a cost function. Terrell's approach has gained increasing acceptance in the literature, fostering several extensions. His approach of constraining a functional form can almost be thought of as imposing "regional concavity," in that he constrains the functional form over *more* than one data point.

Kleit and Terrell (2001) extend this practice further in their study of electricity deregulation. Using a data set which contains plant level cost information from various electricity generating power plants, Kleit and Terrell use the Bayesian cost frontier and the Gibbs sampling technique to concentrate only on a range of prices where inferences were to be drawn. In other words, they imposed regularity conditions over a small range of relative input prices. Specifically, they ignored prices that violated concavity and monotonicity outside their relevant range. Their analysis found that power plants using natural gas as the primary fuel could reduce costs by thirteen percent on average by becoming more efficient. They focus on the electricity industry given the present move toward the deregulation of that industry. It stands to reason that deregulation should force firms to become more efficient, in line with economic theory.

Dorfman and McIntosh (2001) claim that no empirical evidence exists with respect to improved statistical efficiency from imposing inequality restrictions. They use a Monte Carlo experiment that imposes curvature conditions and find that mean square errors of estimated elasticities are greatly improved. This result is seen in both small and somewhat large samples.

This essay uses the translog flexible functional form along with data from the electric utilities industry to estimate a cost function. The interest is to gauge the forecasting accuracy of the translog with and without the imposition of regularity conditions. One of these conditions is concavity, which has been described in detail

above. This chapter follows Terrell's method of imposing restrictions over a range of data points. The primary objective is to determine if forecasting is improved upon the imposition of regularity conditions. If indeed it is, then this implies that economic theory matters in empirical analysis. In other words, imposing economic theory improves empirical analysis. Interestingly, each measure of forecasting accuracy shows that the translog with the constraints imposed performs better than the unconstrained model. Standard deviations are reduced with the restrictions, and the mean square error and mean absolute error are also reduced with the imposition of regularity conditions. This is an important finding that may influence the way economists perform economic forecasting in the future.

Data from the utilities industry is used for a variety of reasons. Electricity is currently an important topic in both national and state political debate. Rolling blackouts in California have caused some residents and pundits to question the effectiveness of electricity deregulation. While regulated firms are provided a guaranteed profit for operation, deregulation makes no such promise. Deregulation encourages cost effectiveness and optimal capital allocation for firms wishing to remain in the industry in the long run. Regulated firms once received profit as a function of capital investment, leading those firms to over-invest in capital. Deregulation would reverse this trend.

Additionally, the process of electricity generation has often been thought of as being that of a natural monopoly. A natural monopoly usually has the characteristic of economies of scale over the entire relevant range of output. Given this, possible new entrants are prohibited from entering the market due to this significant barrier to entry. As a result, the firm can achieve an above reasonable rate of return. Government regulation typically stems from this occurrence.

There are problems with regulation however. One point to address is the proper measure of regulation. That is to say, what price should the government regulate that the power plants may charge? Regulatory authorities must allow for a price of output which provides zero economic profit at the very least. Failure to do so results in exit from the industry. Regulation as a function of capital expenditures only serves to add to the allocative inefficiency which already exists with firms with market power. The second, more normative point to consider when discussing regulation is the political aspect. The

measure of government regulation is the outcome of competing consumer interests and lobby groups operating on behalf of the electrical industry.

With innovations in the transmission of electricity, it is now believed that perhaps electricity generation is not a natural monopoly after all. As a result, there has been a significant movement in several U.S. states toward electricity deregulation. Economic theory suggests that deregulation of the electrical industry would force firms to pursue more cost efficient methods in order to maximize profits in a market setting.

Deregulation invites another problem however. If there are too few plants servicing a given location, then the possibility of collusion presents itself to the firms in the region. Accordingly, prices to consumers could actually become higher under deregulation. This has been a common accusation with respect to the California energy problem of 2000-01. Many pundits have accused oil companies of price gouging consumers in California. Conversely, it is interesting to note that deregulation could possibly lead to output expansion due to economies of scale. Increased output may lead to lower average production costs, hence benefiting consumers.

Section 6.2 of this chapter provides the theoretical requirements of the cost function. The translog functional form mentioned above is presented, as well as its restrictions. Section 6.3 details the data used for the analysis. Section 6.4 provides an outlook on the statistical methodology used, while Section 6.5 presents the empirical findings of the forecasting results. Concluding remarks are provided in Section 6.6.

6.2. The Cost Function:

The importance of cost functions in both basic and advanced economic theory cannot be overstated. The properties of cost functions are a basic tenet in understanding the nuances of production theory. Given that this essay deals with the forecasting accuracy of the translog, it is necessary to provide a brief overview of the theoretical requirements of the cost function.

Allow cost to be a function of output (q) and input price (p), expressed in functional form as $c(q, p)$. Total cost must increase with input price, meaning that $\frac{\partial c}{\partial p} > 0$. This is the property of monotonicity. When a function is monotonically

increasing, at no time can increases in production result in a reduction in total cost. Hence equivalently for monotonicity, $\frac{\partial c}{\partial q} > 0$.

The second fundamental property of the cost function is concavity in input prices. Mathematically, concavity requires that $\frac{\partial^2 c}{\partial p^2} < 0$. This second order condition of the cost function provides the law of conditional input demand. Concavity implies that the underlying demand function is decreasing in input price, resulting in downward-sloping input demand curves. It is this property that is most often violated in the empirical literature.

The third property is homogeneity of degree one in the input price. If the cost function is homogeneous of degree one, then the first derivative of the cost function (which is the conditional input demand) must be homogeneous of degree zero. Homogeneity of degree one requires that $c(tp) = tc(p)$, where $t > 0$. Taking the derivative of this expression with respect to the input price, we have $t\frac{\partial c}{\partial p} = t\frac{\partial c}{\partial p}$, which is the desired result.

It is of interest to assess the potential benefits of imposing regularity conditions locally rather than globally for approximations of the true cost function. This chapter will focus on imposing these conditions on a widely used flexible form: the translog. The model will be estimated using results from a data set generated from Kleit and Terrell's previous work. Using these results, we will forecast with a new data set. Using Bayesian inference, both the constrained and unconstrained models will be estimated as a stochastic frontier. The mean square error, mean absolute error, and mean standard deviation for both the constrained and unconstrained models will then be computed. Despite the sole focus on the translog, the methods used in this essay can easily be extended to other functional forms.

Both the translog and the generalized Leontief approximations often fail to satisfy concavity, even over observed prices in a given sample. For ease of exposition and to emphasize the problem of primary interest, we focus on the verification and imposition of regularity conditions over sets of prices, with monotonicity constraints tested and

imposed at a fixed time period and output level (described below). The reader can think of this as imposing "regional" concavity.

Consider first the translog cost function. With three inputs and two outputs as in this application, the translog cost function is:

$$(1) \qquad \begin{aligned} \ln c(p,q) = \alpha_0 &+ \sum_{i=1}^{3} \alpha_i \ln p_i + \sum_{i=1}^{2} b_i \ln q_i + \frac{1}{2}\sum_{i=1}^{3}\sum_{j=1}^{3} \alpha_{ij} \ln p_i \ln p_j \\ &+ \frac{1}{2}\sum_{i=1}^{2} \gamma_i (\ln q_i)^2 \end{aligned},$$

where: $\alpha_{ij} = \alpha_{ji}$ for all $i, j = 1,2,3$, and

$$\sum_{i=1}^{3} \alpha_i = 1, \quad \sum_{j=1}^{3} \alpha_{ij} = 0 \quad (i, j = 1,2,3).$$

The translog cost function imposes homogeneity of degree one with respect to input prices under these conditions. As a second order approximation to an arbitrary cost function, the translog also fulfills Diewert's minimum flexibility requirement for flexible forms. In terms of this work, it is necessary to take the first derivative of the log cost function with respect to the log input price to find the share equations associated with a respective input:

$$(2) \qquad s_i(p,q) = \alpha_i + \sum_{j=1}^{3} \alpha_{ij} \ln p_j \, .$$

For any given price, the regularity conditions can be verified from restrictions derived from the translog cost function. Monotonicity in the input prices is ensured by nonnegative values of (2). For concavity, the Hessian matrix $\nabla^2 f$ (where f is the cost frontier described below) must be negative semidefinite. Allow $\mathbf{s}$ to be a vector of n share equations. Additionally, let $\hat{s}$ be an $n \ x \ n$ diagonal matrix with the shares making up the main diagonal. Finally, allow A to be an $n \ x \ n$ symmetric matrix of the parameters α_{ij}. Diewert and Wales (1987) show that the translog cost function satisfies concavity if and only if $A - \hat{s} + ss^T$ is a negative semidefinite matrix.

As stated above, monotonicity in output requires that cost increase with output. Given the translog frontier, monotonicity is equivalent to the restriction:

$$(3) \qquad b_i + \gamma_i \ln q_i > 0 \, .$$

Jorgenson and Fraumeni (1981) imposed concavity on the translog by forcing the symmetric matrix A to be negative semi-definite (the Cholesky factorization approach mentioned above, with matrices associated with price effects subject to the condition of being negative semidefinite). As stated earlier, the main problem with imposing restrictions on functional forms to satisfy regularity conditions is that elasticities are adversely affected. The own-price elasticities tend to be overestimated, while cross-price elasticities tend to be biased when A is restricted to be negative semidefinite.[21] In using a prior to impose regularity conditions over a certain *range* of input prices where inferences are to be drawn, Terrell's (1996) method is followed. He found little bias over small ranges, but significant bias as the region was lengthened. This was due to the loss in flexibility as the range of prices in which restrictions were imposed increased. Hence the model became too restrictive.

6.3. Data:

This work uses a data set from the Utility Data Institute (UDI) that includes plant level information concerning total costs, fuel prices, and two measures of output for electricity generating plants for the year 1999. Two measures of output are required to take into account the fact that some power plants exist solely to provide output during periods of peak demand. This data set also provides information on plant location and the average price of natural gas burned at each plant.

The second data source is the Bureau of Labor Statistics (BLS), which provides county level data on manufacturing wages for 1999. The wage rate in this data set is the average annual manufacturing wage for workers in the county where the power generating plant is located.

For the third data source, Hilt (1996) supplies plant level measures of the capital stock, taxes, overhead, depreciation, and operating and management expenses.

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[21] Theorized by Ryan and Wales (1998) using aggregated annual Canadian data on food, clothing, and miscellaneous nondurable commodities from 1947 to 1993.

Allocating firm level data to each plant derives all these variables. Hall and Jorgenson's (1971) method is used to calculate the price of capital using this data set.

Table 6.1 shows the summary statistics of the Kleit-Terrell (2001) data set using 1996 data.

Table 6.1
Summary Statistics for the 1996 Data

N = 78

Variable	Mean	Std. Dev.
Cost (C)	50,653,645.79	51,246,491.93
Annual Output (q_1)	1,537,843.24	1,741,523.54
Peak Output (q_2)	649.32	548.47
Wage	45,342.54	7,196.22
Price of Fuel	2.71	0.46
Price of Capital	1.02	0.39
Log Relative Wage	3.85	0.16
Log Relative Fuel Price	1.03	0.40

Table 6.2 below presents the summary statistics for the 1999 data used in this project.

Table 6.2
Summary Statistics for the 1999 Data

N = 80

Variable	Mean	Std. Dev.
Cost (C)	58,475,601.66	88,083,689.22
Annual Output (q_1)	1,666,551.19	2,003,655.62
Peak Output (q_2)	588.10	554.17
Wage	38,806.66	11,499.69
Price of Fuel	2.70	0.34
Price of Capital	0.91	0.28
Log Relative Wage	19.52	2.24
Log Relative Fuel Price	0.99	0.11

6.4. Methodology:

In this chapter, the Bayesian approach to cost frontier analysis is used. By using Bayesian analysis, one can combine a subjective probability distribution summarizing

what one knows about a parameter, with any available sample information, to obtain a more reflective posterior distribution. This chapter uses the prior distribution from Kleit and Terrell's previous work as the prior for the current sample in this project. In using the prior distribution from the earlier work, current sample information is used to form the posterior. When comparing the predicted results for both the constrained and unconstrained models to the true log cost, it can be seen if forecasting accuracy is improved upon the imposition of regularity conditions.

Allow an efficient firm to be represented by the *cost frontier*, which yields the cost that an efficient plant faces given a vector of prices (p_i) for inputs used to produce a given level of outputs (q_i). The cost frontier for the efficient plant is represented by $f(p_i, q_i)$. If a plant's observed cost exceeds that which would be provided by the frontier, then that deviation is partly attributable to inefficiency. Therefore, any deviations from the frontier can be used to measure plant inefficiency.

As in Kleit and Terrell's earlier work, express the log total cost for the plant as:

$$(5) \qquad \ln(c_i) = f(p_i, q_i) + u_i + v_i.$$

Notice the two error terms. The deviation of plant $i's$ cost from the frontier is comprised of two parts: inefficiency (v_i) and measurement error (u_i). Allow $u_i \sim IIDN(0, \sigma^2)$. The inefficiency error term follows an exponential distribution with a scale parameter λ. The exponential distribution is used because this distribution is more robust with regard to prior assumptions about parameters, moreso than other distributions (as shown in van den Broek, Koop, Osiewalski, and Steel (1994)). Additionally, van den Broek et al. report that the exponential distribution is least affected by the choice of prior median efficiency than other distributions, especially the truncated normal. The truncated normal is the most sensitive to the choice of prior median efficiency; therefore, it is the least desirable choice of inefficiency error distributions.

Combining the cost function above with the translog cost frontier, this yields a linear model which can be expressed as:

$$\begin{aligned} y_i &= X_i \beta + u_i + v_i \\ u_i &\sim N(0, \sigma^2) \\ v_i &\sim EXP(\lambda). \end{aligned}$$

In this model, y_i is the log cost for plant i, X_i is a row vector of independent variables used in order to create the translog frontier, and β is a column vector representing the coefficients of the translog. u_i is a two-sided error term accounting for measurement error, and v_i is a one-sided (non-negative) error term measuring plant inefficiency. This linear error model that combines the cost function with the translog functional form is consistent with the prior information in Kleit and Terrell's previous work.

Recall that we are only concerned with an implicit demand curve with a limited range of prices. Terrell (1996, 2001) uses a prior to impose monotonicity and concavity restrictions. In so following, define the indicator function $h(\beta) = 1$ if the cost frontier satisfies monotonicity and concavity for all price combinations over some region ψ, and zero otherwise. This prior allows us to disregard that portion of the posterior density that violates economic theory in terms of the cost function. This region is defined in terms of relative prices since concavity and monotonicity depend only on relative prices. The prior density is presented as:

$$(6) \qquad \pi(\beta, \sigma^2, \lambda^{-1}) \propto \sigma^{-2} f_G(\lambda^{-1} \mid 1, -\ln(r^*)) h(\beta).$$

Thus, the probability of parameter values will be zero at those prices which violate economic theory (in terms of the cost function, stated as monotonicity and concavity above).

The forecast exercise pursued here was first introduced by van den Broeck et al. (1994), in which they highlighted differences between Bayesian and sampling theory estimation. Their work was a considerable contribution, in that it first pointed out potential advantages of the Bayesian approach over traditional frequentist maximum likelihood methods. van den Broeck et al. presented the basic Gibbs sampling algorithm and derived the required conditional densities. Additionally, they specified four different assumptions about the distribution of the inefficiency error term: the exponential, the half-Normal, the truncated Normal, and a gamma distribution. The van den Broeck et al. results generally favor the exponential distribution, but also provide a method of using a mixture of densities. For purposes here, allow the one-sided error term to be distributed exponentially with scale parameter λ, as shown above.

6.5. Results:

Table 6.3 presents the posterior moments for the model parameters for the 1999 data set. This table also presents the moments for σ^2 and λ as well. The moments for the cost frontier do not reveal much information in and of themselves.

Table 6.4 presents the estimates of shares and elasticities evaluated at the means of the 1999 data. Notice the elasticities in the unconstrained section of Table 6.4. Even if the elasticities of labor and fuel did not seem rather high, the upper band of the confidence interval for the price elasticity of labor is positive. All own-price elasticities are required to be negative in order to obey the law of demand. Additionally, notice how wide the ranges of the confidence intervals appear to be in the unconstrained model.

Now take note of the elasticity estimates in Table 6.4 when regularity conditions are imposed. The own-price elasticities are much lower, and all the confidence intervals are in the negative range (as well as smaller than the unconstrained confidence interval bands).

Furthermore, take note of the estimates of input shares in Table 6.4. In the constrained model, the sum of the input shares is exactly one. As with the Kleit-Terrell 1996 data set, the fuel input has the largest share of total expenditure with 66.5 percent in the 1999 data. Notice that fuel is relatively less responsive when compared with labor and capital. This is true in both the unconstrained and constrained models. Additionally, the positive cross-price elasticities reveal that all the inputs are substitutes. The higher responsiveness of labor and fuel in the constrained model implies that with high fuel prices, there is a relatively larger increase in the hiring of labor. This is especially not surprising given the high prices of natural gas seen over the past two years. The reader should also notice that there is a decline in the size of the confidence intervals with respect to the input shares as well. This suggests that imposing regularity conditions perhaps has some degree of merit for this result alone (at least in finite samples).

Table 6.5 presents the true log cost, constrained and unconstrained predictions of log cost, the constrained and unconstrained standard deviations, and confidence intervals for each of the 80 plants used in the data set. Notice that with 72 of the 80 plants in this data set, standard deviations of the predicted log cost are smaller in the constrained model

Table 6.3
Posterior Moments for Model Parameters (1999 Data)

Unconstrained

Parameter	Mean	Std. Dev.	(90% Confidence)	
α_0	8.268847	2.807612	3.533909	12.740180
α_1	1.400004	1.432968	-0.876390	3.812679
α_2	0.266979	0.945223	-1.280890	1.768683
α_{11}	-0.402520	0.430186	-1.114620	0.277646
α_{12}	-0.608980	0.393311	-1.240110	0.053400
α_{22}	0.279915	0.335776	-0.265490	0.830269
b_1	-0.409440	0.183658	-0.703580	-0.102460
γ_1	0.042398	0.007125	0.030477	0.053707
b_2	0.886982	0.238961	0.493512	1.277616
γ_2	-0.059530	0.019650	-0.091920	-0.027040
σ^2	0.006493	0.002462	0.003049	0.010962
λ	0.142963	0.024579	0.106544	0.186545

Constrained

Parameter	Mean	Std. Dev.	(90% Confidence)	
α_0	9.946819	1.099542	8.117065	11.768950
α_1	0.613998	0.349389	0.090865	1.233522
α_2	0.404890	0.341738	-0.215720	0.895062
α_{11}	-0.139850	0.109720	-0.327160	0.026074
α_{12}	-0.146750	0.136441	-0.385700	0.063880
α_{22}	0.113562	0.116176	-0.060460	0.320443
b_1	-0.442410	0.194860	-0.759200	-0.111860
γ_1	0.043697	0.007581	0.031012	0.056133
b_2	0.844671	0.259985	0.419408	1.278064
γ_2	-0.056530	0.021662	-0.091950	-0.020930
σ^2	0.009723	0.002623	0.006064	0.014493
λ	0.131658	0.021943	0.099385	0.170702

Table 6.4
Shares and Elasticities (1999 Data)
Unconstrained

Shares:

Share	Mean	Std. Dev.	(90% Confidence)	
Labor	0.202096	0.085385	0.065012	0.348750
Fuel	0.624670	0.092594	0.471888	0.774241
Capital	0.173235	0.070182	0.057513	0.287073

Elasticities:

Elasticity	Mean	Std. Dev.	(90% Confidence)	
ε_{LL}	-3.636450	74.585480	-6.636680	1.621731
ε_{FF}	-1.428460	0.833771	-2.899350	-0.202350
ε_{KK}	-3.804160	13.420550	-9.211660	-1.384390
ε_{LF}	2.759033	55.065170	-1.485860	5.051082
ε_{LK}	0.877418	20.393990	-2.507230	3.950150
ε_{FL}	0.695619	0.644188	-0.249390	1.829564
ε_{FK}	0.732840	0.447578	0.064756	1.505893
ε_{KL}	1.419183	12.457810	-1.709040	7.581804
ε_{KF}	2.384977	3.883839	0.652193	3.925281

Constrained

Shares:

Share	Mean	Std. Dev.	(90% Confidence)	
Labor	0.216521	0.071929	0.105998	0.341752
Fuel	0.665102	0.076544	0.534755	0.786324
Capital	0.118377	0.041631	0.053989	0.189734

Elasticities:

Elasticity	Mean	Std. Dev.	(90% Confidence)	
ε_{LL}	-1.406000	0.413301	-1.984020	-0.648810
ε_{FF}	-0.572660	0.294157	-1.111980	-0.182350
ε_{KK}	-1.364170	0.351752	-1.933020	-0.734750
ε_{LF}	1.142737	0.441603	0.331669	1.768726
ε_{LK}	0.263264	0.317361	-0.167830	0.868225
ε_{FL}	0.401014	0.255328	0.068740	0.886014
ε_{FK}	0.171648	0.114489	0.005629	0.376330
ε_{KL}	0.477225	0.556796	-0.319970	1.481717
ε_{KF}	0.886947	0.437835	0.053394	1.470465

than in the unconstrained model. Put another way, imposing regularity conditions reduces the standard deviations of the forecast results for 90 percent of the plants used in this data set. Of course, reductions in standard deviations will occur when restrictions are imposed (even if the restrictions are wrong). However, economic theory tells us that the restrictions imposed are correct. Additionally, imposed restrictions will usually lead to biased estimates of parameters. While this is a concern, it is unavoidable in analyzing whether these restrictions lead to an improvement in forecasting accuracy. Perhaps this bias is acceptable given that forecasting accuracy is improved with the regularity conditions imposed.

Table 6.5
Forecasting Results
Constrained

Plant Name	Log Cost	Pred. Cost	Std. Dev.	(90% Confidence)	
Arsenal Hill	16.252922	16.333833	0.0441	16.260586	16.405796
Atkinson	15.703305	15.770759	0.0319	15.718153	15.823023
Barney Davis	18.535292	18.609303	0.0398	18.544666	18.676263
Baxter Wilson	18.297704	18.363957	0.0446	18.291043	18.437161
Cedar Bayou	19.226843	19.321863	0.0556	19.228021	19.413042
Collins	18.681795	18.440619	0.0750	18.317869	18.560118
Cunningham	17.630857	17.613905	0.0514	17.528946	17.696877
Cutler (FL)	16.674875	16.610974	0.0471	16.529827	16.685505
Decordova	18.978303	18.959113	0.0610	18.859951	19.057524
Deepwater (TX)	16.239577	16.243894	0.0333	16.190048	16.299311
Delta	16.089156	16.049646	0.0515	15.962628	16.132706
Eagle Mountain	17.871886	17.811063	0.0332	17.756339	17.865047
East River	17.620557	16.666136	0.0382	16.601161	16.727517
Eaton	16.320850	16.017825	0.0656	15.909103	16.122666
Edgewater (OH)	16.225093	15.949425	0.0452	15.874472	16.021779
Fort Phantom	17.622623	17.519589	0.0663	17.403660	17.622982
Gadsby	16.737175	16.634196	0.0307	16.583509	16.684424
Gordon Evans	17.412603	17.540953	0.0255	17.499820	17.583167
Graham	18.399801	18.406898	0.0465	18.331330	18.482097
Greens Bayou	17.440212	17.435214	0.0272	17.391228	17.481251
Greenwood (MI)	18.128143	18.109868	0.0375	18.048875	18.170827
Handley	18.773510	18.686296	0.0386	18.622181	18.748588
Harvey Couch	16.117652	15.966181	0.0612	15.860304	16.062034
Hunters Point	17.106716	16.679505	0.0298	16.630966	16.729328
Hutchinson	16.351173	16.214795	0.0305	16.164720	16.265414

Table continued

Plant Name	Lcost	Pred. Cost	Std. Dev.	(90% Confidence)	
Jones	18.162219	18.184393	0.0376	18.123063	18.244946
Knox Lee	17.849076	17.865350	0.0353	17.808295	17.922503
La Palma	16.997574	16.852698	0.0573	16.755962	16.944475
Lake Catherine	17.748058	17.804342	0.0399	17.736967	17.868163
Lake Creek (TX)	17.595882	17.538011	0.0387	17.475329	17.601751
Lake Hubbard	18.618691	18.695177	0.0341	18.638677	18.750961
Lake Pauline	14.804306	14.936307	0.0995	14.767814	15.093371
Laredo	17.108643	16.873494	0.0629	16.765175	16.973516
Lewis Creek	17.474282	17.625303	0.0414	17.560017	17.694201
Lieberman	17.016263	16.921479	0.0287	16.875196	16.970343
Little Gypsy	18.191476	18.325237	0.0304	18.277054	18.375866
Lon Hill	17.947839	17.982295	0.0286	17.935019	18.030204
Lone Star	15.200722	15.486335	0.0748	15.360633	15.607599
Maddox	17.050344	16.893954	0.0637	16.787406	16.996079
Michoud	18.373599	18.473847	0.0329	18.420430	18.528097
Morgan Creek	18.351543	18.428861	0.0318	18.377294	18.480693
Murray Gill	17.101479	17.189551	0.0320	17.137711	17.243545
Mustang	17.599911	17.710851	0.0335	17.655226	17.766372
Nichols	17.790458	17.816847	0.0368	17.757718	17.876525
Ninemile Point	19.324209	19.270541	0.0495	19.188045	19.351478
North Lake	17.920638	17.950378	0.0231	17.912456	17.988500
Northeastern 1 and 2	18.016216	18.117896	0.0282	18.071768	18.164894
Nueces Bay	18.256798	18.369141	0.0382	18.307112	18.433011
Oak Creek (TX)	16.420163	16.196346	0.1016	16.021051	16.356597
Ocotillo	17.457186	16.985248	0.0309	16.935243	17.036595
Paint Creek	16.976115	16.699477	0.1353	16.452905	16.900692
Permian Basin	18.591339	18.546248	0.0571	18.450886	18.638014
PH Robinson	19.483929	19.548209	0.0574	19.452410	19.640452
RE Ritchie	17.262534	16.838355	0.0459	16.764982	16.915811
Reeves	15.816473	15.815101	0.0405	15.746601	15.881408
Rex Brown	16.615228	16.375703	0.0337	16.320363	16.431663
Riverside (GA)	15.643988	15.230608	0.0600	15.130347	15.328308
Riverside (MD)	15.982008	15.523064	0.0618	15.420387	15.623219
Riverside (OK)	15.946740	15.492867	0.0613	15.390470	15.592654
Sabine	19.295722	19.430308	0.0542	19.341983	19.517304
Saguaro	17.006794	16.747423	0.0531	16.659473	16.834008
Sam Bertron	17.916518	17.896727	0.0254	17.856155	17.938418
Seminole (OK)	18.974392	18.905659	0.0442	18.831880	18.976670
Sewaren	16.931109	16.572584	0.0357	16.513302	16.631691
Southwestern	17.352056	17.353920	0.0336	17.297993	17.408230
Starlington	17.356003	17.515005	0.0251	17.474484	17.556764
Stryker Creek	18.376017	18.452166	0.0355	18.394234	18.510413
Sweatt	16.166326	16.005662	0.0575	15.909349	16.096730

Table continued

Plant Name	Lcost	Pred. Cost	Std. Dev.	(90% Confidence)	
TH Wharton	17.050828	16.702459	0.0568	16.603973	16.792534
Tradinghouse Creek	19.292814	19.304122	0.0477	19.225355	19.382143
Tulsa	17.279701	17.241717	0.0322	17.188908	17.294695
Turkey Point 1 and 2	18.588415	18.650254	0.0540	18.559802	18.737638
Valley (CA)	16.635837	15.397986	0.0759	15.272624	15.520209
Victoria (TX)	17.413635	17.544047	0.0250	17.503293	17.585868
Waterford 1 and 2	18.125560	18.219819	0.0282	18.175559	18.267139
Waterside (NY)	17.374463	16.896688	0.0386	16.832290	16.959512
West Springfield	16.458346	15.348194	0.0395	15.284693	15.414397
Wilkes	18.096972	18.128897	0.0505	18.043439	18.208330
Willow Glen	18.780305	18.746638	0.0460	18.670470	18.822747
Zuni	14.601351	14.591436	0.0679	14.475400	14.701229

Unconstrained

Plant Name	Lcost	Pred. Cost	Std. Dev.	(90% Confidence)	
Arsenal Hill	16.252922	16.338825	0.0444	16.266665	16.412239
Atkinson	15.703305	15.805465	0.0373	15.743622	15.865759
Barney Davis	18.535292	18.630451	0.0399	18.565876	18.696453
Baxter Wilson	18.297704	18.365313	0.0862	18.218214	18.499490
Cedar Bayou	19.226843	19.319804	0.0613	19.217032	19.417019
Collins	18.681795	18.448003	0.0695	18.331482	18.561327
Cunningham	17.630857	17.641848	0.0525	17.554599	17.727421
Cutler (FL)	16.674875	16.639695	0.0579	16.542918	16.731779
Decordova	18.978303	18.958116	0.0675	18.847343	19.067949
Deepwater (TX)	16.239577	16.241884	0.0392	16.177198	16.305699
Delta	16.089156	16.052789	0.1030	15.881629	16.211532
Eagle Mountain	17.871886	17.799803	0.0402	17.732911	17.864009
East River	17.620557	16.621171	0.0504	16.535539	16.699490
Eaton	16.320850	16.033404	0.0650	15.927669	16.142057
Edgewater (OH)	16.225093	15.963902	0.0481	15.886262	16.044610
Fort Phantom	17.622623	17.531127	0.0923	17.370946	17.678423
Gadsby	16.737175	16.672900	0.0329	16.619359	16.726802
Gordon Evans	17.412603	17.563680	0.0270	17.520076	17.608155
Graham	18.399801	18.427162	0.0477	18.348712	18.505821
Greens Bayou	17.440212	17.448221	0.0285	17.401737	17.494403
Greenwood (MI)	18.128143	18.093611	0.0482	18.014246	18.173361
Handley	18.773510	18.679042	0.0432	18.607121	18.749393
Harvey Couch	16.117652	15.970983	0.0865	15.824994	16.107925
Hunters Point	17.106716	16.693977	0.0340	16.640028	16.751111
Hutchinson	16.351173	16.251211	0.0327	16.197588	16.305822
Jones	18.162219	18.221282	0.0368	18.161922	18.281889

Table continued

Plant Name	Lcost	Pred. Cost	Std. Dev.	(90% Confidence)	
Knox Lee	17.849076	17.897349	0.0355	17.839919	17.957795
La Palma	16.997574	16.858205	0.1062	16.682731	17.025414
Lake Catherine	17.748058	17.839485	0.0546	17.746596	17.926636
Lake Creek (TX)	17.595882	17.540659	0.0438	17.470219	17.614165
Lake Hubbard	18.618691	18.679348	0.0435	18.606685	18.750331
Lake Pauline	14.804306	14.840388	0.1124	14.658441	15.028222
Laredo	17.108643	16.886629	0.0924	16.732150	17.034898
Lewis Creek	17.474282	17.542902	0.0830	17.399177	17.669151
Lieberman	17.016263	16.931925	0.0315	16.880784	16.984065
Little Gypsy	18.191476	18.337140	0.0394	18.272827	18.401381
Lon Hill	17.947839	18.007485	0.0300	17.959326	18.057766
Lone Star	15.200722	15.427062	0.0744	15.306332	15.550851
Maddox	17.050344	16.903050	0.0655	16.795183	17.011667
Michoud	18.373599	18.513728	0.0339	18.459052	18.570055
Morgan Creek	18.351543	18.469522	0.0329	18.416135	18.523542
Murray Gill	17.101479	17.171525	0.0386	17.107877	17.233292
Mustang	17.599911	17.734711	0.0381	17.673050	17.798164
Nichols	17.790458	17.842810	0.0376	17.782707	17.906462
Ninemile Point	19.324209	19.304705	0.0500	19.219498	19.385551
North Lake	17.920638	17.984052	0.0261	17.941748	18.027147
Northeastern 1 and 2	18.016216	18.155706	0.0296	18.108209	18.204201
Nueces Bay	18.256798	18.389823	0.0384	18.327695	18.453503
Oak Creek (TX)	16.420163	16.158384	0.1772	15.861135	16.440222
Ocotillo	17.457186	16.996610	0.0315	16.945197	17.047879
Paint Creek	16.976115	16.601997	0.2628	16.153056	17.026028
Permian Basin	18.591339	18.569090	0.0626	18.463621	18.669585
PH Robinson	19.483929	19.546285	0.0622	19.440911	19.644722
RE Ritchie	17.262534	16.743667	0.1371	16.509859	16.951569
Reeves	15.816473	15.843404	0.0477	15.764674	15.919666
Rex Brown	16.615228	16.369741	0.0506	16.283296	16.448321
Riverside (GA)	15.643988	15.238554	0.0595	15.141471	15.337377
Riverside (MD)	15.982008	15.478594	0.0612	15.380509	15.578784
Riverside (OK)	15.946740	15.455960	0.0601	15.358924	15.555070
Sabine	19.295722	19.446738	0.0538	19.356663	19.534843
Saguaro	17.006794	16.747872	0.0551	16.659919	16.839853
Sam Bertron	17.916518	17.921031	0.0272	17.877407	17.965226
Seminole (OK)	18.974392	18.922173	0.0471	18.845588	19.000370
Sewaren	16.931109	16.591810	0.0378	16.529668	16.652769
Southwestern	17.352056	17.397632	0.0353	17.339366	17.454695
Starlington	17.356003	17.544546	0.0283	17.499287	17.592304
Stryker Creek	18.376017	18.482608	0.0370	18.422778	18.544379
Sweatt	16.166326	16.026432	0.0603	15.928618	16.125258
TH Wharton	17.050828	16.703647	0.0664	16.594307	16.810623

Table continued

Plant Name	Lcost	Pred. Cost	Std. Dev.	(90% Confidence)	
Tradinghouse Creek	19.292814	19.319886	0.0485	19.239873	19.399193
Tulsa	17.279701	17.247654	0.0380	17.186153	17.310762
Turkey Point 1 and 2	18.588415	18.672877	0.0581	18.576382	18.768091
Valley (CA)	16.635837	15.421978	0.0770	15.291125	15.541299
Victoria (TX)	17.413635	17.583278	0.0285	17.537282	17.630846
Waterford 1 and 2	18.125560	18.231735	0.0362	18.171454	18.290637
Waterside (NY)	17.374463	16.924264	0.0401	16.858697	16.989954
West Springfield	16.458346	15.342683	0.0548	15.250360	15.428192
Wilkes	18.096972	18.157329	0.0652	18.044088	18.261728
Willow Glen	18.780305	18.747759	0.0545	18.657049	18.835232
Zuni	14.601351	14.609290	0.0686	14.491636	14.711711

Looking at a couple of plants more closely, the benefits of imposing regularity conditions on the translog can more fully be illustrated. For example, the true 1999 log cost of the Paint Creek plant is 16.976. By imposing constraints, observe that the standard deviation falls from 0.2628 in the unconstrained model to 0.1353 in the constrained model. Now notice the RE Ritchie plant. It has a true log cost of 17.263. When imposing constraints, the standard deviation falls from 0.1371 in the unconstrained model to 0.0459 in the constrained model.

Lastly, notice Table 6.6. This table presents the measures of forecasting accuracy. Specifically, this table shows the mean square error (MSE), the mean absolute error (MAE), and the mean standard deviation (SD). Notice that the constrained model outperforms the unconstrained model in every measure. The MSE, MAE, and mean SD are each smaller in the model with regularity conditions imposed than in the

Table 6.6
Measures of Forecasting Accuracy

Model	MSE	MAE	Mean SD
Constrained	0.079726	0.171554	0.046285
Unconstrained	0.082342	0.176922	0.056743

unconstrained model. However, when estimating a two-tailed t-test with a 0.05 level of significance, the absolute value of the t-statistic is 1.2006, with a two-tailed critical value of 1.9905. Since the absolute value of the t-statistic is not greater than the critical value,

one cannot conclude that there is a *statistically significant* improvement in forecasting accuracy. Additionally, an ANOVA table was constructed, and with respect to the source of variation between the constrained and unconstrained models, the F-statistic was found to be 0.0047, with an F critical value of 3.901. There is a small improvement in forecasting accuracy, and these restrictions should be imposed if they are correct. Since economic theory tells us that these restrictions are correct, therein lies the motivation for their imposition. Using Bayesian analysis is a much simpler method than frequentist studies when imposing restrictions, and the issue of loss of flexibility is not as prevalent.

To further note the benefits of imposing regularity conditions, marginal density plots were generated for the input shares and own-price elasticities from both the unconstrained and the constrained models. The density plots for the unconstrained model can be found in Figure 6.1. Regarding the input shares, notice that the plots for the labor

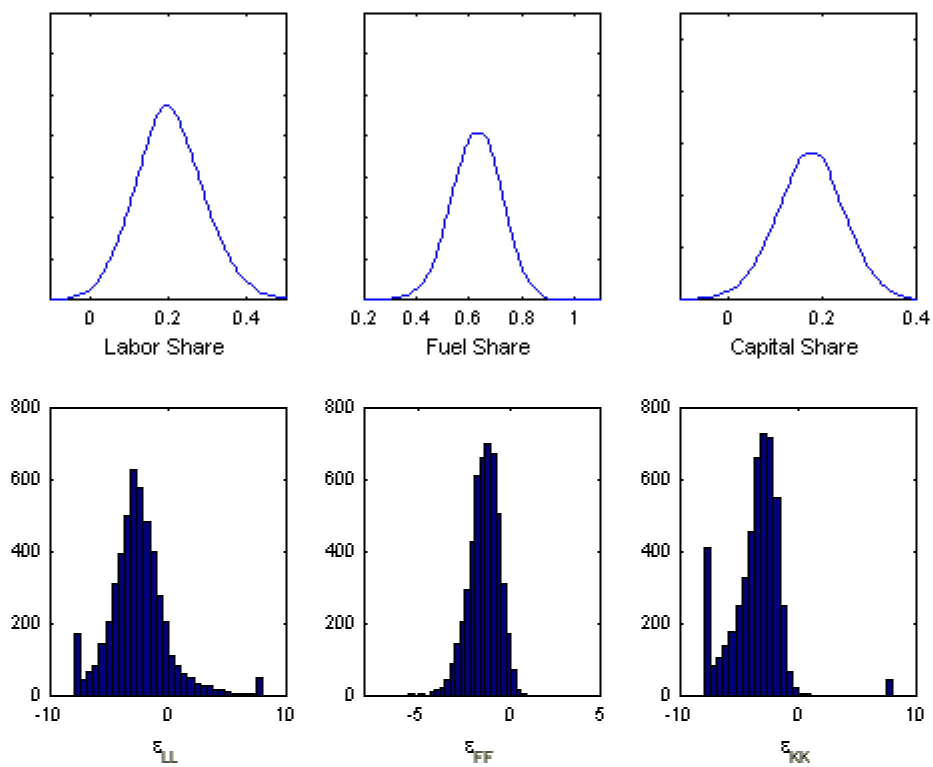

Figure 6.1—Unconstrained Plots

and capital shares may be less than zero. This is an odd result in that a firm cannot employ a negative share of input. With respect to the elasticity histogram plots, the price elasticity plot for fuel suggests that the own-price elasticity for this input can be greater than zero. This violates demand theory. The same can be said for the histogram plots of labor and capital elasticities. These diagrams also illustrate violations of economic theory. Histogram plots were constructed in this case because of a few data points that existed so far outside the others. These few points are compressed in the outside bars of the histogram plots, hence their size. Posterior density plots would have been flat in this case, and therefore uninteresting to present.

The marginal density plots for shares and elasticities from the constrained model are presented in Figure 6.2. Notice that with respect to the input shares for capital and

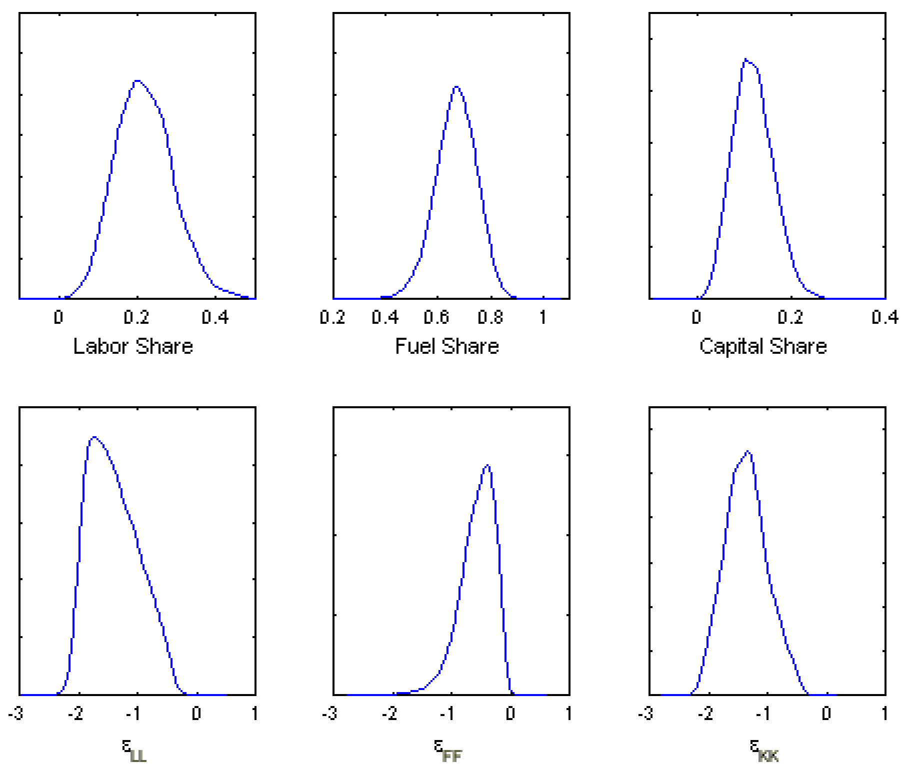

Figure 6.2—Constrained Plots

labor, the input shares are constrained to be at least positive. The input share for fuel is also positive, and constrained to be less than one. Regarding the own-price elasticities,

notice that each input elasticity is constrained to be less than zero. This is in accordance with economic theory and the law of demand. Notice that these constrained density plots illustrate a direct link to the theoretic restrictions that were imposed. Specifically, the negativity of input demand elasticities which are crucial in economic theory.

6.6. Conclusion:

In the introduction above, it was noted how some of the previous literature of estimating cost functions led to biased and inaccurate estimates of elasticities. In this essay it was shown that, when imposing regularity conditions on a flexible form in estimating a cost function, elasticities were well behaved, and the standard deviations of predicted cost were reduced. Combining the Bayesian cost frontier with a flexible form such as the translog, concavity was imposed over a range of input prices that did not violate economic theory. This constrained model yielded more accurate forecasts than the unconstrained model. Using the mean square error, the mean absolute error, and the mean standard deviation as measures of forecasting accuracy, all three statistics were smaller with the imposition of regularity conditions. This suggests that forecasting is improved when imposing constraints on a cost function. This key result, as well as the results presented above in the corresponding tables and figures, provides an important conclusion for economists: economic theory matters.

CHAPTER SEVEN
CONCLUSION TO THE DISSERTATION

This dissertation has presented a thorough analysis of issues in theoretical and applied microeconomics. The second chapter provided a comprehensive review of the literature concerning integration issues in international trade. This review showed the tremendous research that has been devoted to furthering the understanding of horizontal and vertical integration in the context of international trade theory. The selected research and the subsequent review provided a background that might suggest the proper placement for the integration essays which followed. The final essay was an analysis of cost theory and the translog flexible functional form. This essay first presented a review of the literature concerning the estimation of cost functions. Empirically, economic theory is sometimes violated when attempting to estimate cost functions. These violations of theory will lead to inaccurate parameter estimates, and biased own-price and cross-price elasticities. As a result, regularity conditions (monotonicity, concavity, and first-degree homogeneity) are sometimes imposed on a functional form to correct these errors. This essay concludes with an analysis of forecasting accuracy. Specifically, the motivation is to find if forecasting is improved with the imposition of regularity conditions. If so, then this may provide a significant contribution to the literature regarding the future estimation of cost functions.

The essay presented in Chapter Three provided an analysis of horizontal integration in international trade. The Brander-Krugman reciprocal dumping model was used given its simplicity and wide acceptance in the international trade literature. It assumes a world duopoly. The extension described in this essay provided for a variable that represented a degree of ownership. It was seen that in a situation of non-controlling interest, as the domestic (acquiring) firm increased its degree of ownership in the foreign firm, the domestic firm increased both its exports and production for domestic consumption. Conversely, the foreign firm decreased its exports and production for foreign consumption. Intuitively, the domestic firm reduces its total output in favor of its acquisition. The degree of ownership variable also represents the fraction of foreign firm profit that accrues to the domestic firm. In this situation, foreign firm profit increases as the domestic firm increases its acquisition of the foreign firm. This is due to the fact that

the foreign firm sees an increase in market share in both the domestic and foreign markets.

Somewhat counterintuitive results abound when the domestic firm acquires enough of the foreign firm to obtain managerial control (a majority ownership setting). In this situation, it is the domestic firm that increases its total output (exports plus output for indigenous consumption), while the foreign firm reduces its total output. The paradoxical result is that even in the presence of transportation costs, the domestic firm chooses to *increase* its exports. The high elasticity of domestic output in the foreign market is the likely rationale for this result. But more importantly, it is due to the fact that the domestic firm has become a multiplant monopoly, with the foreign firm becoming a subsidiary. Foreign firm profit falls with increased ownership by the domestic firm. This is due to the fact that the foreign firm loses market share in both markets with this ownership setting. Domestic firm profit must increase in the managerial control situation. Monopoly profits *must* be greater than symmetric duopoly profits.

The first essay does not evaluate the optimal level of domestic firm ownership of the foreign firm. In fact, the essay implicitly does not allow for the provision of corner solutions. This is the motivation for the second essay presented in Chapter Four.

Given the comparative statics results from the third chapter, an evaluation of optimal asset ownership is presented in Chapter Four. Specifically, this chapter provides an analysis of horizontal integration in the presence of external constraints (such as antitrust or nationalist constraints). Given these constraints, Kuhn-Tucker programming is used to find the optimal level of ownership that the domestic firm should acquire. Whereas the third chapter illustrated ownership exogenously, the fourth chapter endogenizes the degree of ownership variable. It was found that the optimal level of ownership occurs when the domestic firm obtains complete and absolute ownership of the foreign firm. With the assumption of antitrust constraints, it was found that the optimal level of ownership is the maximum level of ownership that is allowed by the nation's government. If the constraint on ownership is due to nationalism (hence a foreign government constraint), then the optimal level of ownership is again the maximum level that is allowed (by the foreign government).

The essay presented in the fifth chapter provided a study of vertical integration effects in international trade. In this chapter, an upstream duopoly is assumed to be located in a home market. The downstream market is a three-firm oligopoly, with one firm located in the home market, and one firm located in two foreign countries. A four-stage Cournot-Nash game was presented, and backward induction was used to find the subgame perfect Nash equilibrium. In the presence of tariffs, when a foreign downstream firm vertically integrates backward with one of the upstream firms in the home market, this newly integrated firm finds it necessary to prevent counterintegration. The integrated firm assumes a price leadership role in the input market. With the assumption of strategic internal transfer pricing, any increase in the input price above marginal cost (yet below the monopoly input price) will forestall potential counterintegration by the home downstream firm.

When the home nation's government imposes tariffs on downstream imports, firms located in that country wish to increase production with the increase in price. With strategic internal transfer pricing and input price leadership, any increase in input price prevents these downstream firms from pursuing this type of behavior. The increase in input price will increase the cost of production. As a result, downstream rivals may wish to merge with the remaining unintegrated upstream firm. By choosing to sell the input to its downstream rivals, the vertically integrated firm can prevent the input price from reaching such a level that might provoke counterintegration. As a result, counterintegration is prevented. With strategic internal transfer pricing, the vertically integrated firm not only forecloses its downstream rivals from the contested home market, but forecloses *itself* as well. With all downstream firms reducing their output levels in the home market, the firms approach a collusive equilibrium. This occurs in the absence of even tacit collusion among the downstream rivals.

The final essay presented in Chapter Six views a key issue in applied microeconomics. Cost theory is of fundamental importance in economics. As mentioned above, empirical research in estimating cost functions sometimes leads researchers down misleading paths due to inaccurate and biased estimates. As a result, many economists have chosen to impose regularity conditions on flexible functional forms in order to

estimate a cost function. This "constrained" model allows for the satisfaction of key properties such as monotonicity and concavity.

Chapter Six is devoted to estimating the forecasting accuracy of the translog with and without the imposition of these regularity conditions. Cost and output data from 80 electricity generating firms using natural gas as the primary fuel are used in conjunction with Bayesian cost frontier analysis. The mean square error, mean absolute error, and mean standard deviation are all computed as the measures of forecasting accuracy. When comparing the true log cost figures to both the constrained and unconstrained predicted values, it was found that each measure of forecasting accuracy showed improvements when using the constrained model. This important result is one that may fundamentally influence empirical analysis in future research.

In conclusion, there are a variety of possible avenues to future research that are suggested by this dissertation. Regarding international trade theory and integration, a further analysis of asset ownership in an oligopolistic setting could be pursued. An interesting motive of research would be to study the effects of asset ownership in a managerial control setting with the assumption of more than two firms. A comprehensive study of welfare analysis could also provide valuable insight into the effects of horizontal and vertical integration. Additionally, changing the number of upstream and/or downstream firms in the vertical integration study may be an interesting course of research. Further manipulation of the input market may provide some direction for future study. Lastly, the empirical essay in this dissertation indicates a variety of possibilities for future papers. A similar study could be conducted with respect to electricity generating plants burning coal as the primary fuel. Also, the imposition of regularity conditions on flexible functional forms is not sector-specific. Using other industries would provide for an interesting exercise to see if the results in this dissertation are consistent.

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APPENDIX A

PROOF OF INPUT PRICE EQUALLING MARGINAL COST

Allow the profit function from an upstream supplier to be denoted as:

$$\pi^{U_j} = w(x^i)x^i - mx^i \; ; \; j = 1,2; \; i = \text{A,B,H},$$

where:

$w(x^i)$ is the input price, where one unit of input produces one unit of output

x^i is total input demanded by downstream firms

m is the marginal cost of input production.

Differentiating:

$$\frac{\partial \pi^{U_j}}{\partial x^i} = w'(x^i)x^i + w(x^i) - m = 0$$

Rearranging:

$$w(x^i) + w'(x^i)x^i = m$$

Factoring out the input price:

$$w(x^i)[1 + \frac{dw}{dx^i}\frac{x^i}{w(x^i)}] = m\,.$$

If s_i is allowed to be the share of input business by an upstream supplier, then $s_i = \frac{x^i}{X}$, which means then that $x^i = s_i X$, where X equals total input demand by all firms. Substituting this expression into the above equation yields:

$$w(x^i)[1 + \frac{dw}{dx^i}\frac{X}{w(x^i)}s_i] = m\,.$$

The second term in brackets is simply the input share multiplied by the reciprocal of the elasticity of market input demand, resulting in:

$$w(x^i)[1 + \frac{s_i}{\varepsilon}] = m \text{ ; where } \varepsilon = \text{elasticity of market input demand.}$$

Since there is an input duopoly, each upstream firm has a significant share of the market; therefore, s_i is not small. However, given that ε is equal to infinity since the inputs are

perfect substitutes for one another, $\frac{s_i}{\varepsilon}$ approaches zero, meaning that the bracketed term equals one. This implies then that $w(x^i) = m$.

APPENDIX B

DERIVATION OF BEST RESPONSE FUNCTIONS

$$\pi^M = p(X)x^M - c(w, x^M) - \tau x^M + w(X)[r^H(w) + r^B(w)] - m[r^H(w) + r^B(w)]$$

$$\frac{\partial \pi^M}{\partial x^M} = p'(X)x^M + p(X) - c_x - \tau + w'(X)[r^H(w) + r^B(w)]$$

$$\frac{\partial^2 \pi^M}{\partial x^{M^2}} = p''(X)x^M + 2p'(X) - \frac{\partial^2 c}{\partial x^{M^2}} + w''(X)[r^H(w) + r^B(w)] < 0$$

provided that $p''(X)$ and $w''(X)$ are both negative.

$$\frac{\partial^2 \pi^M}{\partial x^M \partial x^H} = p''(X)x^M + p'(X) + w''(X)[r^H(w) + r^B(w)] < 0$$

Using the implicit function theorem in finding the slopes of the best response functions, it is seen that:

$$\frac{dx^H}{dx^M} = -\frac{p''(X)x^M + p'(X) + w''(X)[r^H(w) + r^B(w)]}{p''(X)x^M + 2p'(X) - \frac{\partial^2 c}{\partial x^{M^2}} + w''(X)[r^H(w) + r^B(w)]} < 0\,.$$

Given that $\frac{dx^H}{dx^M} < 0$, the best response functions slope downward in $(x^M - x^H)$ space.

VITA

Dennis S. Edwards has completed six years of graduate work at Louisiana State University in Baton Rouge, Louisiana. His areas of expertise are international trade and finance, with minor areas in monetary theory and econometrics. Prior to graduate school, he attended Murray State University in Murray, Kentucky, graduating in 1995. He was awarded several academic honors, including Outstanding Senior in Economics. Dennis Edwards was recognized three times for outstanding teaching during his time at Louisiana State University. He completed his Master of Science degree from Louisiana State University in 1999. The next year, Edwards took a position as Visiting Assistant Professor of Economics at Centre College in Kentucky, where he currently teaches.

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