Board of Governors of the Federal Reserve System

International Finance Discussion Papers

Number 459

November 1993

UNION BEHAVIOR, INDUSTRY RENTS, AND OPTIMAL POLICIES

Phillip Swagel

ABSTRACT

This paper examines the welfare gains from strategic trade and industrial policy in the U.S. steel industry, focusing particularly on the potential gains from capturing labor rents. I take into account product market distortions such as price-setting firms, factor market distortions in the form of union-created labor rents, and the presence of fixed capital and underutilized capacity in U.S. steel production.

The existence of underutilized capacity means that firms respond to protection by reducing the share of labor in production, eliminating the rents targeted by the policy and thus reducing the potential gains. At the same time, the union takes advantage of protection to "skim off" rents, further reducing the effectiveness of the optimal policy. Taking into account these endogenous responses substantially reduces the welfare gains from optimal policies. And simply reducing domestic labor market distortions results in a welfare gain nearly as large as that from optimal policies. This suggests that the focus on labor rents as the subject of U.S. trade and industrial policy is overstated, at least in manufacturing industries such as integrated steel.

Union Behavior, Industry Rents, and Optimal Policies

Phillip Swagel *

1 Introduction

The long decline of large US manufacturing industries such as steel and automobiles has brought continued calls for protection from import competition. Many of the industries for which import restrictions have been sought are "high-wage/good-job" manufacturing industries. These are often unionized industries characterized by tense labor relations in the context of declining employment.

These calls for protection appear to be supported by recent empirical work, which indicates that there are relativey large welfare gains to be had from strategic trade policies when labor rent is taken into account. As noted by Katz and Summers (1989a) and Dickens and Lang (1988), even though there is only a small amount of product market rent to be captured, factor market distortions can mean that the very act of producing is desirable, since this brings with it labor rents. In Dixit's (1988) study of the U.S. automobile industry, for example, the gains from optimal policies are about eight times larger when labor rents are taken into account—$2 billion versus $250 million when they are ignored.

*The author is a staff economist in the Division of International Finance. I thank Judith Hellerstein, Kala Krishna, Ana Revenga, and Tan Ling Hui for extremely useful discussions, Alberto Alesina, Ernst Berndt, Don Davis, Joe Gagnon, Ann Harrison, Bill Helkie, Dale Jorgenson, Larry Katz, and Cathy Mann for helpful suggestions, and Catherine Morrison for both discussions and for generously providing data. I am grateful to many seminar participants for comments which led to improvements throughout this paper, which is substantially revised from an earlier version. The views expressed here are solely those of the author, and are not necessarily shared by the Federal Reserve System or its staff.

Katz and Summers (1989b) document the existence of labor rents, particularly in manufacturing industries. Proponents of activist trade policies use this evidence to argue that the existence of industry-specific labor rents leads to socially inefficient underproduction and thus underemployment, and seek to remedy the inefficiency through trade protection or industrial subsidies.

This paper evaluates the focus on labor rents by simulating the effects of optimal trade and industrial policies in the U.S. market for integrated carbon steel. The steel industry is among the most likely industries in which labor rents are to be found. All production workers belong to a single union, and wages are substantially above those for other manufacturing industries.

I model competition between US, Japanese, and European (EC) firms in the US steel market over the years 1973 to 1986. I explicitly model the wage-setting process in order to take account of the possible source of labor rents, as suggested by Eaton (1988). I obtain measures for union bargaining power vis-a-vis the firm, and then examine the implications of the union's strategic behavior on the gains from optimal policies. As shown by Eaton and Grossman (1986) firm interactions are crucial to the determination of optimal policies in imperfectly competitive industries. A firm which acts collusively will raise prices more than a competively-behaving firm in response to protection; this behavior affects consumers surplus and thus the gains from policies. Rather than assuming a particular form of behavior, the model is used to obtain measures of firm behavior.

I also explicitly take into account the existence of fixed capital and underutilized capacity in the steel industry. Since labor and capital are complements in steel production, the presence of fixed but underutilized capital leads firms to employ "too much" labor relative to what they would use were capital fully employed. This increases union bargaining power, and allows the union to capture a larger share of industry rents.

In addition to allowing the union to capture rent, underutilized capacity leads to declining average costs, as increased production allows firms to choose an input mix closer to what would be optimal were capacity fully utilized. However, taking firms' cost-minimizing behavior into account reduces the gains from optimal policies. This is because firms adjust their input mix to reduce the share of labor as utilization increases, lessening the importance of labor rents as compared to the case with constant marginal costs.

Moreover, the existence of a strategically acting union acts as a drain on the effectiveness of policies, because the union raises its wage and thus "skims off" rents captured by government policy. This in turn affects firms' pricing decisions, so that optimal policies result in less reduction in prices, and thus less of an increase in consumers surplus. When the actions of both firms and unions are considered, labor rents provide a far smaller welfare gain than that indicated by previous studies which neglected these endogenous responses.

Finally, substantial gains are to be had not only by capturing factor market rents, but also by eliminating the underlying distortions. Reductions in union power typically lead to gains in welfare of about two-thirds the size of the most active (and perfectly informed) trade policy. This paper thus serves to reaffirm that US policy should focus first on the domestic sources of any competitive disadvantage. I thus conclude that the focus on labor rents as the object of trade policy is overstated, at least in large-scale manufacturing industries such as integrated steel.

The paper proceeds as follows. Section 2 sets forth the model, after which I describe the data in Section 3. Implementation of the model and calibration results are in Section 4. In Section 5, I then use the model to simulate the effects of optimal trade and industrial policies. Section 6 presents sensitivity analysis, after which Section 7 concludes with a discussion of implications for policy.[1]

2 A Model of the Steel Industry

I model competition in the US steel market between US, Japan, and EC integrated steel producers over the years 1973 to 1986. I do not include steel produced by mini-mills, which have become

[1] Fuss, Murphy, and Waverman (1992) examine the impact of trade policies and exchange rate shocks on the U.S., Canadian, and Japanese automobile industries in a model which includes some of the same elements as this one. In particular, they allow for both imperfect competition between firms as well as scale effects in production, the latter through the use of the cost function methodology of Fuss and Waverman (1992). However, they do not model the wage-setting process, but instead take labor rent as fixed, as in Dixit (1988).

increasingly important in the latter part of the 1980's. These mini-mills tend to produce more sophisticated alloys, and are thus differentiated from the carbon steel industry. Though other nations have become important in US steel imports, as late as 1986, Japan and the EC accounted for 51% of US steel imports, down from 80% in 1973.

Figure 1 shows the timing structure of the model. The U.S. government moves first, and commits to policies—specific production subsidies and tariffs—before wages and prices are set. Of course, the government takes union and firm responses into account in setting optimal policy, and the union takes into account firms' response in setting wages; that is, the equilibrium is subgame perfect.

Since steel contracts typically last three years, I assume that wages in each year are set before firms set prices. The union and firms bargain over wages, using the Nash Bargaining Equilibrium as the solution concept. I first calibrate for the union's bargaining power vis-a-vis the firm, and then use this wage-setting process to simulate the response of wages to government policies.

Firms then compete by setting prices to maximize profits, taking wages and other factor prices as given. As discussed in Crandall (1981), Hogan (1983), and Old (1985) it is generally acknowledged that US firms face substantially underutilized capacity as a result of fixed capital such as plants and equipment. To model this, I estimate a cost function in which fixed capital results in short-run diminishing average costs. The estimated cost function is then used to simulate the effect of changes in wages on US firms' costs and thus on pricing decisions and demand. I do not model production in Japan or the EC, but rather assume that wages and thus costs in those countries do not respond to US policies. While not strictly correct, this is probably not too bad an assumption, since exports to the US account for less than 7% of Japanese production and less than 6% of EC production over 1973 to 1986.

After firms set prices, demand is satisfied as the steel market clears. As usual, the model is solved backwards; the details follow in similar order.

2.1 Demand

Figure 2 presents an overview of the demand side of the model. Consumers of steel services choose between US steel (U, on the left) and foreign steel (F, on the right). The parameter σ denotes the elasticity of substitution in demand between the two. The longer lead times and warehousing costs associated with ordering foreign steel are often cited as giving rise to this differentiation. Within foreign steel, consumers choose between Japanese steel, J, and EC steel, E, where σ_F denotes the elasticity of substitution between the two. This form considerably simplifies the demand equations, at the expense of imposing particular restrictions on cross-elasticities between goods from the three countries. Because data are available for only a limited number of years, the model is calibrated a year at a time.

Steel is produced within the US, Japan, and EC by n_U, n_J, and n_E firms, respectively, with σ_U, σ_J, and σ_E denoting the elasticity of substitution between the steel produced by different firms within each of the countries. This last level of differentiation is crucial, since any markup of price over marginal cost with homogenous goods implies behavior less competitive than Bertrand, and I do not want to restrict firms' behavior.

Demand is parametrized with constant elasticity of substitution (CES) functional forms; this is similar to Krishna, Hogan, and Swagel (1990) (henceforth KHS). A level of steel "services" S is demanded by an aggregate consumer who receives all profits and revenues, and maximizes a utility function of the form:

$$\mathcal{U} = m + \beta S^{\alpha}$$

where m is a numeraire good, and S is the level of steel services consumed in the US market.

Steel services are "produced" from the US and Foreign aggregate goods U and F using the CES household production function:

$$S = (U^{\rho} + F^{\rho})^{1/\rho}$$

where ρ (which equals $\frac{\sigma}{\sigma-1}$) parametrizes the elasticity of substitution σ between domestic and foreign steel.

The US aggregate good U is in turn composed of the outputs of n_U domestic firms, each of which produces q_U^i:

$$U = \left(\sum_{i=1}^{n_U} (q_U^i)^{\rho_U} \right)^{1/\rho_U}$$

where ρ_U parametrizes the elasticity of substitution (σ_U within US goods.

The foreign aggregate good F is composed of the aggregate Japan good J and the aggregate EC good E, with ρ_F parametrizing the elasticity of substitution, σ_F, between foreign steels:

$$F = (J^{\rho_F} + E^{\rho_F})^{1/\rho_F}$$

The aggregate Japan good J and the aggregate EC good E are in turn made from individual firms' outputs q_J^i and q_E^i, with ρ_J and ρ_E parametrizing the elasticities of substitution σ_J and σ_E:

$$J = \left(\sum_{i=1}^{n_J} (q_J^i)^{\rho_J} \right)^{1/\rho_J}$$

$$E = \left(\sum_{i=1}^{n_E} (q_E^i)^{\rho_E} \right)^{1/\rho_E}$$

The demand for the steel produced by an individual firm in any of the countries is a derived demand, and can be obtained by calculating the demands for the corresponding aggregate goods in the demand for steel services S. Unit input requirements for aggregate goods U, F, J, and E, and for individual firms' goods q_U^i, q_J^i, or q_E^i are obtained by differentiating the cost functions implied by the corresponding demand functions.

The CES production function for S generates the cost function, C:

$$C = (C_U^{1-\sigma} + C_F^{1-\sigma})^{\frac{1}{1-\sigma}}$$

where and C_U and C_F are the costs of the aggregate US and Foreign goods U and F, which are not directly observable. The marginal cost of producing steel services, C, is similarly unobservable. As noted above, the elasticity of substitution between US and foreign steel is $\sigma = 1/(\rho - 1)$; elasticities of substitution between Japan and EC steel (σ_F) and within each country (σ_U, σ_J, and σ_E) are analogous.

Equating the marginal utility of S with its marginal cost gives the demand for steel services:

$$S = \left(\frac{C}{\alpha\beta}\right)^{\frac{1}{\alpha-1}}$$

The price elasticity of demand for services, ϵ, is then:

$$\epsilon = -\frac{\partial S}{\partial C}\frac{C}{S} = \frac{1}{1-\alpha}$$

From the cost function for services, C, $\frac{\partial C}{\partial C_U}$ is the number of units of the aggregate US good U needed to produce a service S. If p_U is the price of a ton of steel produced by a US firm, then $\frac{\partial C_U}{\partial p_U}$ is the unit input requirement for each US firm in the aggregate US good U. The demand for a particular US firm's product q_U^i is thus:

$$q_U^i = S\,\frac{\partial C}{\partial C_U}\,\frac{\partial C_U}{\partial p_U}$$

The partial derivatives are easily obtained from the corresponding CES cost functions. These are fully derived in Appendix A.

Demands for Japan and EC firms are slightly more complicated, since the unit-input requirements of aggregate goods J and E in the aggregate foreign good F must also be considered.

Let C_J and C_E denote the costs of the aggregate Japan and EC goods, and p_J and p_E denote the price of the steel produced by individual Japan and EC firms. The demand for the steel produced by each Japan and EC firm is thus:

$$\begin{aligned} q_J^i &= S\,\frac{\partial C}{\partial C_F}\,\frac{\partial C_F}{\partial C_J}\,\frac{\partial C_J}{\partial p_J} \\ q_E^i &= S\,\frac{\partial C}{\partial C_F}\,\frac{\partial C_F}{\partial C_E}\,\frac{\partial C_E}{\partial p_E} \end{aligned}$$

Again, Appendix A provides the fully worked out functional forms.

I next assume symmetry between the firms within a country, and use the numbers-equivalent of the Herfindahl index to calculate the number of firms. Since the steel produced by each firm is different, however, this should be taken as an approximation, since the equivalent number of symmetric firms would be endogenous. Again, what is most important is that I do not assume homogenous goods, for to do so is to restrict firms' behavior to be more collusive than Bertrand.

Summing the demands for US steel q_U^i over the n_U domestic firms gives the total demand for domestic steel, which I denote as Q_U:

$$Q_U = \frac{n_U^{\frac{1}{1-\sigma_U}}}{(\alpha\beta)^{\frac{1}{\alpha-1}}} C_U^{-\sigma} \left(C_U^{1-\sigma} + C_F^{1-\sigma}\right)^{\frac{(1-\alpha)\sigma+1}{(\alpha-1)(1-\sigma)}} \tag{1}$$

Similarly, summing the demands for Japan and EC steel over the n_J and n_E firms gives total demands Q_J and Q_E:

$$Q_J = \frac{n_J^{\frac{1-\sigma_F}{1-\sigma_J}} p_J^{-\sigma_F}}{(\alpha\beta)^{\frac{1}{\alpha-1}}} C_F^{-\sigma} \left(C_U^{1-\sigma} + C_F^{1-\sigma}\right)^{\frac{(1-\alpha)\sigma+1}{(\alpha-1)(1-\sigma)}} \tag{2}$$

$$Q_E = \frac{n_E^{\frac{1-\sigma_F}{1-\sigma_E}} p_E^{-\sigma_F}}{(\alpha\beta)^{\frac{1}{\alpha-1}}} C_F^{-\sigma} \left(C_U^{1-\sigma} + C_F^{1-\sigma}\right)^{\frac{(1-\alpha)\sigma+1}{(\alpha-1)(1-\sigma)}} \tag{3}$$

The three markets are assumed to clear, so that Q_U, Q_J, and Q_E are observable as actual sales. The data on the number of firms n_U, n_J, and n_E, and prices p_U, p_J, and p_E are described in Section 3.

2.2 Price-Setting

The next step is to examine firms' pricing decisions. A US firm i sets price p_U^i to maximize profits π_U^i:

$$\max_{p_U^i} \pi_U^i = (p_U^i + s) q_u^i (\vec{p}_U, \vec{p}_J, \vec{p}_E) - \mathrm{TC}(q_U^i)$$

where $\mathrm{TC}(q_U^i)$ is the total cost for firm i and s is the specific subsidy to domestic production. The vector notation for $\vec{p}_U$, $\vec{p}_J$, and $\vec{p}_E$ indicates that demand for each firm's steel depends on the prices of all firms, both foreign and domestic. The existence of underutilized capacity leads to declining average costs as output expands towards full capacity, so that marginal cost c_U is not constant, but is instead a function of output, $c_U(q_U^i)$. Of course, output depends on prices, so that profit-maximization must be solved simultaneously with cost-minimization.

Profit maximization gives the first order condition:

$$\epsilon_{UU}^{ii} - \gamma^U = p_U^i / (p_U^i - c_U(q_U^i) + s) \tag{4}$$

where ϵ^{ii}_{UU} is the US firm's own-price elasticity of demand:

$$\epsilon^{ii}_{UU} = -\frac{\partial q^i_U}{\partial p^i_U}\frac{p^i_U}{q^i_U}$$

Demand elasticities depend on the prices of all competitors, both the other $n_U - 1$ domestic firms, and Japan and EC firms. Appendix B derives the exact form of the demand elasticities. There are four of these for each country: firm i's own elasticity, the price elasticity of firm i with respect to the price of firm j in the same country (ϵ^{ij}_{UU} for US firms), and the two "cross-country" derivatives (ϵ^{ij}_{UJ} and ϵ^{ij}_{UE}). Price elasticities for Japan and EC firms are denoted similarly.

The second term on the left hand side of the U.S. first-order condition, γ^U, is an aggregate conjectural variations (CV) parameter which summarizes US firms' competitive behavior. Note that CV's are used here only as a convenient means by which to parametrize firm behavior in this static model.

The aggregate CV γ^U is made up by the firm's specific reactions to its domestic and international competitors:

$$\gamma^U = (n_U - 1)\epsilon^{ij}_{UU}\gamma^{UU} + n_J\epsilon^{ij}_{UJ}\frac{p_U}{p_J}\gamma^{UJ} + n_E\epsilon^{ij}_{UE}\frac{p_U}{p_E}\gamma^{UE}$$

where the γ^{ab}'s are the conjecture of a firm in country a over the response of firms in country b:

$$\gamma^{UU} = \frac{\partial p^j_U}{\partial p^i_U} \qquad \gamma^{UJ} = \frac{\partial p^j_J}{\partial p^i_U} \qquad \gamma^{UE} = \frac{\partial p^j_E}{\partial p^i_U}$$

Note that $\gamma^U = 0$ corresponds to Betrand behavior, $\gamma^U < 0$ reflects behavior more competitive than Bertrand, and $\gamma^U > 0$ implies behavior more collusive than Bertrand. I discuss the calibrated values for the CV's in Section 4.2.

First order conditions for Japan and EC firms are:

$$\epsilon^{ii}_{JJ} - \gamma^J = p^i_J/(p^i_J - c_J - t) \tag{5}$$

$$\epsilon^{ii}_{EE} - \gamma^E = p^i_E/(p^i_E - c_E - t) \tag{6}$$

where c_J and c_E are the constant marginal costs of production, and t is a specific tariff on steel imports.

The aggregate Japan and EC CV's are:

$$\gamma^J = n_U \epsilon^{ij}_{JU} \frac{p_J}{p_U} \gamma^{JU} + (n_J - 1)\epsilon^{ij}_{JJ}\gamma^{JJ} + n_E \epsilon^{ij}_{JE} \frac{p_J}{p_E} \gamma^{JE}$$

$$\gamma^E = n_U \epsilon^{ij}_{EU} \frac{p_E}{p_U} \gamma^{EU} + n_J \epsilon^{ij}_{EJ} \frac{p_E}{p_J} \gamma^{EJ} + (n_E - 1)\epsilon^{ij}_{EE}\gamma^{EE}$$

where:

$$\gamma^{JU} = \frac{\partial p^j_U}{\partial p^i_J} \qquad \gamma^{JJ} = \frac{\partial p^j_J}{\partial p^i_J} \qquad \gamma^{JE} = \frac{\partial p^j_E}{\partial p^i_J}$$

$$\gamma^{EU} = \frac{\partial p^j_U}{\partial p^i_E} \qquad \gamma^{EJ} = \frac{\partial p^j_J}{\partial p^i_E} \qquad \gamma^{EE} = \frac{\partial p^j_E}{\partial p^i_E}$$

2.3 The Cost Function for Steel

I estimate a restricted (or "partial static equilibrium" (PSE)) translog cost function for US firms. The capital input is assumed to be fixed in each year, while firms optimize over the variable inputs of labor, energy, materials, and services.[2] One can think of the "short-run" as the period over which the capital stock is fixed (not necessarily at the optimal level), while the "long-run" is the period over which firms adjust investment so that capital is at the cost-minimizing level. In the short-run, capital can be "underutilized" in the sense that the level of the capital stock is higher than it would be if capital was not fixed but was rather in long run equilibrium. Note that firms do not actually leave capital idle; the stock of capital is simply larger than optimal.[3] Underutilized capital results in short-run declining average costs, since a higher level of output means that the stock of capital moves closer to the cost-minimizing level.

Morrison (1988) estimates a similar cost function for the steel industry, though she assumes perfect competition, includes capital used to comply with environmental regulations as a second fixed factor, and omits services. In general my results are similar to hers, though her assumption of perfect competition means that some rents which are the result of firms' market power are instead

[2] As Dale Jorgenson has stressed, fixing the capital stock means that this is an incomplete model, since over time firms do in fact choose the level of investment. Morrison (1991) and Berndt (1990) discuss models which incorporate investment dynamics into a PSE framework.

[3] The existence of fixed costs associated with shutting down (buying mothballs, for example) and then restarting a plant (taking out the mothballs) might explain why firms do not concentrate production sooner in a smaller number of plants. In the spirit of the literature on hysteresis and irreversible investment surveyed by Pindyck (1991), if plant restarts involve a fixed cost, then keeping an underutilized plant on-line has an option value which arises from the possibility that demand might pick up.

attributed to capital. This makes capital appear to be more valuable, and thus less underutilized. I allow for imperfect competition, and find slightly larger scale effects.

Denote total variable cost by VC, so that total cost TC equals variable costs plus the fixed cost of capital: $\text{TC} = \text{VC} + P_K K$, where P_K is the price per unit of capital, K. The restricted translog variable cost function is:

$$\begin{aligned}\log \text{VC} \;=\;& \beta_0 + \sum_i \log(P_i/P_M) + \log(P_M) + \beta_K \log(K/Q_U) + \beta_t t + \log(Q_U) \\ &+ 0.5 \sum_{ij} \gamma_{ij} \log(P_i/P_M) \log(P_i/P_M) + 0.5\gamma_{tt} t^2 + 0.5\gamma_{KK} \log(K/Q_U)^2 \\ &+ \sum_i \gamma_{iK} \log(P_i/P_M) \log(K/Q_U) + \sum_i \gamma_{it} t \log(P_i/P_M) + \gamma_{Kt} t \log(K/Q_U)\end{aligned} \tag{7}$$

where P_i is the price of factor i, where $i = L$, E, and S for labor, energy, or services, P_M is the price of materials (the normalizing input), K is the beginning of period quantity of capital input, t is a time counter to allow for exogenous technological change, and Q_U is the output level.

I impose the restrictions of symmetry, $\gamma_{ij} = \gamma_{ji}$; homogeneity, $\sum_i \beta_i = 1$, $\sum_i \gamma_{ij} = \sum_i \gamma_{iQ_U} = \sum_i \gamma_{it} = \sum_i \gamma_{iK} = 0$; and constant returns to scale (CRS) at full capacity, $\beta_{Q_U} = 1 - \beta_K$.

I also estimate share equations for the variable factors, dropping one share equation (materials). The share equation for factor i, where i, j are again L, E, and S:

$$\text{Share}_i = \beta_i + \sum_J \gamma_{ij} \log(P_j/P_M) + \gamma_{iK} \log(K/Q_U) + \gamma_{it} t$$

In order to allow for imperfect competition, I add an equation for the "shadow" share of capital. This equates marginal cost (MC) with marginal revenue (MR), where MR is derived from a CES demand function for US steel:[4]

$$\frac{p_U Q_u}{g} = 1 - \beta_K - \sum_J \log(P_j/P_M) - \gamma_{KK} \log(K/Q_U) - \gamma_{Kt} t + \beta_1 \beta_2 \frac{Q_u^{\beta_2+1}}{\text{VC}}$$

where β_1 and β_2 are demand parameters to be estimated.

Preliminary estimation indicated the presence of first-order serial correlation (AR1), so I implement a Berndt-Savin AR1 correction. As discussed by Berndt (1990), the error terms can be thought of as arising from mistakes made by firms in cost minimization.

[4] Lack of pre-1973 data for EC and Japan precludes estimation of the entire demand system (1) - (3).

The data used to estimate the cost function are BLS data from 1949 to 1986 for SIC 3312, blast furnaces and steel mills. These data are slightly different than that used by Morrison (1988): I use a few more years (Morrison pools overlapping samples of US and Canadian data) and have the extra factor input of services, but do not differentiate between capital used for production and capital used to comply with environmental regulations.

Since wages and other factor prices are set before firms set prices, these are properly taken as exogenous. Firms' market power, however, implies that output decisions are not exogenous with respect to costs. I thus employ Zellner's Iterated Three Stage Least Squares (I3SLS), using the log of aggregate US real investment, the log of the Money Supply (M2), and the log of industrial production for final goods as instruments for the log of steel output, Q_U.

Since the actual coefficients are not particularly interesting (though 18 of the 26 are significant at the 5% level, with two more significant at the 10% level), I report only the summary statistics shown below.

COST FUNCTION ESTIMATION

R^2 from Iterated 3SLS

Equation	Capital Fixed	No Fixed Factors
log Cost	.93	.65
Labor share	.85	.94
Energy share	.97	.95
Services share	.87	.78
Capital share	.98	.94

The column on the left of the table above is for the PSE cost function with capital fixed; the column on the right is for the translog cost function where all factors can adjust. It is clear that the cost equation, which is used in the simulations, fits much better when capital is fixed.

Figure 3 shows the estimated cost function plotted for 1978 (with quantity shown as a proportion of actual output), while Figure 4 plots the variable and total cost elasticities for all years. Since the variable cost elasticity is always greater than one in Figure 4, the slope of the marginal cost curve in Figure 3 is always positive.

If capital were fully utilized, the total cost elasticity would equal one from the assumption of CRS; a value less than one indicates underutilized capacity and thus declining short run average costs. The degree of utilization corresponds to the gap between marginal cost and average cost in Figure 3. Until 1968 capacity was generally overutilized in the sense described above that average cost was less than marginal cost. The decline in capacity utilization from 1968 to 1970 and then again after 1981 were accompanied by calls for protection from steel imports. I leave aside the question of why firms apparently overinvested in capital after 1968. That they did, however, has implications for trade and industrial policies, since protection not only captures product and factor market rents, but also changes firms' input mix and lowers costs through increasing utilization.

Capital and labor are complements in production, which matches the results for U.S. manufacturing industries discussed in Berndt (1990). After 1968 this means that US firms' optimal choice of inputs is overly labor intensive relative to what would be optimal were capital at its long run level. For the short-run in which capital is fixed, complementarity in production between labor and capital combined with underutilized capital thus gives the union more power to capture rents in the form of a higher wage bill, since the union knows that the firm will be biased towards labor use.

2.4 Wage-Setting: Bargaining between Union and Firms

Wages are determined after the government sets policies, but before firms compete, so that firms take wages (and other factor prices) as given in setting prices. Wages are determined by bargaining between a union which maximizes labor rents and firms which maximize profits.[5] An infinite supply of labor is available, so that employment is determined by labor demand, which is in turn derived from the demand for steel. This is thus the "right to manage" model, since workers and firms

[5]Oswald (1985) provides an excellent survey of the literature on unions.

bargain only over wages, after which the firm is free to determine the level of employment.

This is not "efficient bargaining" in the sense of Leontief (1946) or McDonald and Solow (1981), because the union and firms bargain only over wages, and not over both wages and employment. Efficient bargaining turns the US firm into a Stackelberg leader vis-a-vis foreign firms, since it fixes the amount of the labor input and thus restricts the range over which US firms choose their cost-minimizing bundles of the remaining factors. While not completely satisfactory, bargaining only over wages avoids this asymmetry. The other possibility, assuming that wages are set at the same time as prices, is also unsatisfactory, since wages do not change as often as prices.[6]

I employ the Nash Bargaining Solution to find the equilibrium.[7] The union maximizes its labor rent, while firms maximize profits:

$$\max_{w} \left[(w - \overline{w})L\right]^{\theta} \left[(p_U + s)Q_U - \mathrm{TC}(Q_u)\right]^{1-\theta}$$

where $\overline{w}$ is the alternative wage for steel workers, L is hours of labor input, and θ indicates the bargaining "power" of the union.

The wage w is the hourly compensation rate for steel workers, including benefits and pensions. I take $\overline{w}$ as the average wage for US manufacturing workers.[8] Section 3 details data sources. It is then straightforward to use the demand equations (1) - (3), firms' first order conditions (4) - (6), and the estimated cost function (7) to solve for union power, θ, in the first order condition of the Nash Bargaining equation.[9] A value of $\theta = 1$ indicates a monopoly wage-setting union which maximizes its labor rent, while smaller values for θ correspond to wages lower than those set by a monopoly union.

[6] MaCurdy and Pencavel (1986) and Brown and Ashenfelter (1986) test between efficient and inefficient bargaining in the typesetting industry. While both find support for efficient bargaining, neither is able to reject the labor demand model of wage determination.

[7] A note of caution is in order here. The Nash Bargaining Solution is a cooperative solution, and the union-firm wage-setting process is not necessarily best described as cooperative. While the Nash Bargaining Solution can be obtained as the outcome of a non-cooperative game—Binmore, Rubinstein, and Wolinsky (1986) is the canonical example—it might be best to think of this wage-setting process as a descriptive device rather than as a strict behavioral assumption.

[8] Of course, some of the wage premium of steel workers over other manufacturing workers might be a consequence of specific skills possessed by steel workers, in which case $\overline{w}$ is too low.

[9] Because the equations for price-setting are nested within the wage-bargaining, the resulting first order condition is a mess of algreba. The details are available from the author.

The results of calibrating for union behavior are discussed in Section 4.3, and then used to simulate the effects of government policies in Section 5. I also experimented with a wage-setting process in which a monopoly union sets a wage to maximize a Stone-Geary preference function over wages and employment. Because the union holds a large degree of bargaining power in most years, this gives very similar results for the optimal policy simulations.

3 Data

Data other than the BLS data used to estimate the cost function come from Paine-Webber *World Steel Dynamics* (WSD), the American Iron and Steel Institute (AISI), and the International Iron and Steel Institute (IISI). All figures are per metric ton, and all prices and costs are deflated by the Producer Price Index to 1978 dollars. The non-BLS data is available from 1973 to 1988, though lack of the BLS factor input data precludes use of the post-1986 data. Unfortunately, foreign data are not available for the years prior to 1973.

For US firms, I use AISI total shipments for quantity Q_U, and domestic list price for p_U. For Japan and EC firms, I use AISI figures for total imports Q_J and Q_E (converting all quantities to metric tons), and Japanese and EC export prices plus freight costs (both from WSD) for p_J and p_E. In all years, Q_E includes imports from all eventual EC members—imports from the UK and Spain are included before either joined the EC. The EC price is the production share-weighted average of prices in the UK, France, and Germany.

To obtain average US costs, I divide the price given in WSD by the markup of price over average costs implicit in the BLS data. Marginal costs are then calculated from the cost function. For Japan costs, I multiply the US marginal cost by the percentage cost advantage (or disadvantage) of Japanese firms cited in WSD. Costs for EC firms are obtained in the same way, with the EC cost differential being a weighted average as with price.

For hourly wage, w, I use the per hour employment cost of US firms at the actual operating rate from *WSD* for 1978, and multiply this by the BLS employment cost index for steel for the other years. The WSD employment cost includes the estimated value of all benefits and pension. Over 1973 to 1986, the simple correlation between BLS and WSD employment costs is 0.987. I use the average wage rate for manufacturing workers from the BLS for the reference wage $\overline{w}$.

US Herfindahl-numbers equivalents come from AISI production data, while number-equivalents for foreign firms are calculated from production data available in various IISI publications.

Finally, I specify a tariff of $20 (in 1978 dollars) on both Japan and EC goods for each year; this roughly corresponds to the actual ad valorem MFN tariff rate which varied from 5 to 6%.

4 Calibration

The data are calibrated to equations (1) through (6) (3 demand, 3 supply) and the cost function (7). There are 10 unknowns to determine: firms' behavioral parameters γ^U, γ^J, and γ^E, the elasticity of demand ϵ (which determines α), the scale parameter β which reflects the strength of demand, and the substitution parameters σ, σ_U, σ_F, σ_J, and σ_E.

The calibration method is similar to that of KHS. Values for ϵ, σ, σ_F and σ_E are taken from the literature, and then the model is solved for year-by-year values for the remaining six parameters. Section 6 provides sensitivity analysis over a range of estimates for the assumed parameters.

An alternative calibration strategy would be to assume Bertrand behavior on the part of firms, so that $\gamma^U = \gamma^J = \gamma^E = 0$. This would leave only one parameter to be taken from outside sources. As shown by Eaton and Grossman (1986), however, the nature of competition between firms is crucial to the direction of optimal policies, and there is no reason to believe that firms behave Bertrand. Similarly, there is no reason to believe that firms in the three nations behave symmetrically. Rather than pin down behavior in an unrealistic way, I assume plausible values for the elasticities and then use these to measure behavior.

De Melo and Tarr (1992) cite estimates for the price elasticity of demand for steel, ϵ, which range from 0.42 to 1.64, with a central figure of 0.81. For utility to be concave, ϵ must be greater than one. I thus take ϵ to be 1.1. For the elasticity of substitution between US and foreign goods, they cite a range from 1.1 to 5.0; I use their central estimate of 3.05.

This leaves σ_F, and σ_E. I assume that $\sigma < \sigma_F < \sigma_E$; that is, from the point of view of a steel consumer in the US, there is a greater distinction between choosing US versus foreign steel than in choosing between the particular type of foreign steel. The second inequality, $\sigma_F < \sigma_E$, specifies that within foreign steel, EC firms are more similar to one another than they are to Japanese firms. I set $\sigma_F = 5.0$ and $\sigma_E = 7.0$. Again, the sensitivity analysis of Section 6 shows that the results do not depend on these numerical choices.

Given these values, the other parameters are easily obtained. I Solve for σ_J by dividing (3) into (2), and then for σ_U by dividing (2) into (1). The first order conditions (4) to (6) provide γ^U, γ^J, and γ^E, after which any of the demand equations (1) - (3) can be used to obtain β.

4.1 Calibration Results

Table 1 contains the results for the calibrated parameters. The demand shift parameter β scales the utility function to match the actual size of the market, and gives an indication of the strength of demand in each year. The values for β show that 1982 marked the beginning of a string of lousy years for the steel industry. This matches the analysis given in *World Steel Dynamics*, as well as the measure of capacity utilization in Figure 4.

The next two columns are the elasticity of substitution within US goods σ_U, and the elasticity of substitution within Japanese goods, σ_J. For all years, σ_U is smaller than σ, which is in turn smaller than σ_F, σ_J, and σ_E. US goods are thus more differentiated from one another than they are from all foreign goods, both in aggregate and within Japan and EC firms. The elasticity of substitution within Japanese steel, σ_J, is typically slightly smaller than σ_E, the elasticity within EC steel. It is important to note again that varying the assumed elasticity values do not greatly affect the optimal welfare results. Better estimates for ϵ, σ, σ_F, and σ_E would, however, help to more accurately measure firm behavior.

4.2 Firm Behavior

The right three columns of Table 1 show the conjectural variations parameters (γ's) which measure firm behavior. US behavior is always more competitive than Bertrand ($\gamma^U < 0$), while foreign firms are always more collusive than those in the US, and nearly always more collusive than Betrand. Note that the much-maligned Trigger Price Mechanism (TPM) put into place in 1978 coincides with a one-year increase in the degree of collusiveness exhibited by firms in all 3 countries. This is not the case when "voluntary" import restraints are imposed in 1983, as all three competitors behave more competitively, not more collusively as would be expected from Krishna (1989). This may stem from the drastic fall in demand for steel in the 1980's, which may have made the import restrictions far from binding. This would reduce the degree to which the quota facilitates collusion between firms. Since the TPM was imposed during a period of relatively healthy demand, it seems to have had a stronger anti-competitive effect.

To more easily interpret the calibrated results for firm behavior, Table 2 shows actual prices and costs as well as the prices that would have resulted had firms conjectures been Bertrand or Cournot. Appendix C explains how to calculate the Bertrand and Cournot-equivalent prices. Actual US prices are far lower than both the Bertrand and Cournot-equivalent prices, showing that US firms seem to act quite competitively. Price of firms in Japan and the EC, on the other hand, are typically substantially above those for both Bertrand and Cournot behavior. The prices consistent with Bertrand and Cournot behavior are not that far from each other; this highlights the arbitrariness of assuming a particular type of behavior such as Bertrand or Cournot in a differentiated products oligopoly. On the whole, these results provide evidence that US firms behaved more competitively than their Japan and EC rivals.

4.3 Union Behavior

Table 3 presents the results for union behavior. The first column, θ, denotes the union's bargaining strength in the Nash Bargaining equilibrium. The rise in union power starting in 1982 coincides with the beginning of several very bad years for the industry. The combination of rising wages but declining profits has led observers to believe that the US steel industry is in an "end game" (Lawrence and Lawrence (1985)). In an end game, the union, realizing that the domestic steel industry and thus steel jobs are in inexorable decline, takes advantage of fixed capital to extract rents, even though this hastens the industry's decline. Lawrence and Lawrence point out that this explains why real wages in steel have far outpaced average wages of other manufacturing workers, even while firm profits and employment in steel have fallen. Demand eventually falls enough to cause firms to shut down plants, thereby reducing overcapacity and limiting union power. This may correspond somewhat with the slight dropoff in union power after 1984, as steel firms shut plants and slightly reduced their underutilized capacity.

The remaining columns in Table 3 show the wages and the division of rents between workers and firms which result from the following two experiments. The 50% columns present the values that result if the union power parameter θ is reduced by half, while the max columns show the values that result if union power is increased halfway to $\theta = 1$. The columns labelled "s.q." show the actual, status quo, values. The "ΔWelfare" columns show the change in US welfare (in \$billions) from these experiments, while the "Labor's Share Rent" columns show the fraction of rent captured by the union, with the next two columns indicating the magnitude of the rents. Consistent with the end game, the union indeed captured an increasing share of total industry rents in the face of declining demand and capacity utilization after 1981.

The results of the 50% columns show that even without activist trade or industrial policies, a less powerful union would have resulted in substantially lower wages and lower steel prices, and a welfare gain of 1 to 2 billion dollars. Increased profits offset about 60-65% of the drop in labor rents, while the increased consumer surplus equals another 45-50%, accounting for the gain in welfare. This net increase in welfare suggests that reducing labor market distortions is not merely a matter of dividing up rents between the two narrow interest groups of workers and firms, but is instead of general economic concern. The "max" results show a similar picture, but in reverse, though the high initial levels of union power mean that the welfare losses from larger labor market distortions are somewhat smaller.

The results of these two experiments imply that policies which alleviate domestic factor market imperfections—that is, which "bust the union"—are likely to have substantial welfare benefits without the need for policies which bear the risk of retaliation by trading partners.

5 Optimal Policies

I next use the calibrated model to simulate the effects of optimal tariffs and subsidies. The government sets its policy to maximize welfare, which is the sum of consumer surplus, labor rents, firm profits, subsidy costs, and tariff revenues. Note that the actual level of welfare is uninteresting, since this depends completely on the CES parametrization. Instead, I focus on comparing the changes in welfare from various policies and assumptions.

Tables 4 to 7 show the policies, wages and welfare results for several different cases: for wage setting I use both the Nash-Bargaining wage-setting process as well as the assumption that wages reflect the marginal product of labor, so that there is no labor rent. I also examine the extent to which the welfare gains from optimal policies are affected by taking into account the diminishing average costs which come about from underutilized capacity, as compared to the fixed costs used in previous work.

Table 4 presents results for an optimal tariff when the difference between the steel wage and the average manufacturing wage is taken as labor rent, both with wage-bargaining and underutilized capacity (top) and with fixed wages and costs (bottom). The first thing to notice is that in all years the welfare gains from an optimal tariff are very small, reaching \$100 million in only one year. This lack of responsiveness of welfare to tariffs is familiar from Dixit (1988), and comes about because trade policies are simply not efficient instruments with which to target what are essentially domestic distortions of firm and union market power. Because of this, I do not report results for an optimal tariff in the case without labor rents, for which the welfare gains are even smaller.

When wage-bargaining occurs, as in the top half of Table 4, the optimal tariff in all years but 1974 is actually lower than the status quo level of $20. Essentially, the government lowers tariffs in order to "hurt" domestic firms. This induces lower wages and thus the setting of lower prices. While these slight changes have only a small effect on domestic production, imports rise by 10% to 20% (not shown in the tables). This gives the net gain in welfare, as the increase in consumers surplus offsets lower profits and labor rents.

Optimal tariffs are typically much larger in the bottom of Table 4, which corresponds to the assumptions used in previous studies: labor rents exist, but wages are fixed and capacity utilization ignored, so that costs are fixed at the initial level. With wages fixed, the sum of tariff revenues, firm profits, and labor rents dominates the loss to consumers surplus. Again, however, the welfare gains involved are small, particularly compared to the size of steel industry.

Tables 5 through 7 show the effects of an optimal production subsidy to domestic firms. Welfare gains here are potentially substantial. Table 5 shows the results when underutilized capacity is present, both with wage-bargaining and labor rents (top) and without (bottom). Table 6 shows the analogous results without underutilized capacity, so that costs and factor shares are fixed. In both tables, considering labor rents results in a stronger policy (larger subsidy) and larger welfare gains.

Comparing Tables 5 and 6, however, shows that taking wage-bargaining and underutilized capacity into account dramatically reduces the gains from the production subsidy. Whereas the top of Table 6 (with labor rents) shows over a four-fold increase in welfare gains over the bottom (no labor rents), the welfare gain in Table 5 with labor rents is typically only about twice that without labor rents.

The principal reason for the smaller welfare gain than in previous studies is that firms adjust their input mix in response to the subsidy. As discussed above, with underutilized capacity, firms start from a position of using "too much" labor compared to the amount they would use were capital fully utilized. As the production subsidy causes domestic production to rise, the cost-minimizing input bundle shifts away from labor, so that the share of labor falls. In Table 5, the labor input increases by only about half as much as output, while in Table 6, the labor share is fixed, so that labor grows proportionately with output. In seeking to capture labor rents, policy diminishes their importance. This is particularly true in later years when there is a larger amount of underutilized capacity, so that the initial labor share is farther above firms' desired level.

The response of wages and price-setting to the subsidy also contributes to the smaller welfare increases of Table 5. As in Brander and Spencer (1988), the union "skims" the rents from the production subsidy by negotiating a higher wage. This offsets the cost-reducing benefits of increased utilization, so much so that average costs rise in all but two years of Table 5. As a result, domestic firms pass through less of the subsidy in the form of lower prices, so that the quantity of U.S. steel, rises by less than when wages and costs are fixed. Even in 1985 and 1986, when there is enough underutilized capacity so that average costs fall, the drop in prices is proportionately far smaller than when costs are fixed. In the top of Table 6, where wages and costs do not change, the optimal policy is both stronger and more than completely passed through; that is, domestic prices fall by more than the amount of the subsidy. This again shows the importance of not constraining firm behavior, since the degree of competition between firms determines the degree to which prices change in response to costs.

This interaction between the wage-setting process and firms' price-setting provides an empirical counterpart to Rodrik (1987), who shows that all relevant distortions must be considered in determining the effects of policies.

Table 7 presents results for another possible mechanism for wage determination: that a wage differential exists, but that the gap is fixed and does not change with trade policy. This might occur if steel firms paid workers a premium over other manufacturing workers for "efficiency wage" reasons, as in Krueger and Summers (1988). An optimal subsidy is slightly more effective in raising welfare when the wages are fixed because the union does not raise wages and skim off the policy However, the welfare gains are still dramatically lower than in Table 6. This shows that underutilized capacity and the resulting changes in input demand in response to protection is the principal factor in explaining the smaller welfare gains shown here.

I also experimented with a labor subsidy paid to the firm per hour of labor hired. Since this more directly targets the largest market imperfection, it gives slightly larger welfare increases than the production subsidy. However, the wage subsidies required are extremely large—over \$100 per hour. This entails expenditures of \$10 to 15 billion for a net welfare gain of only about \$1 billion. Although this is a partial equilibrium model, if one factors in a distortion created by raising the revenues needed to fund this subsidy, then the far less costly production subsidies are preferable.

Finally, note that the optimal policy results depend crucially on the timing structure—on the government's ability to move first. Matsuyama (1990) examines the case where wages are determined before policy, and shows that the union and firm would collude in a way which would leave the government no choice but to "rescue" the affected industry. Further work might be of interest here, particularly to measure the size of the change in welfare which results from the ability of the government to precommit.

6 Sensitivity Analysis

Table 8 shows the effects of varying the elasticity of demand, ϵ, and elasticities of substitution, σ, σ_F, and σ_E. For the sake of brevity, results are shown only for 1978—other years yield similar results. Also, rather than varying each of the parameters individually, I present two cases which are representative of the extensive sensitivity analysis performed: a "low" elasticities case with demand and substitution elasticities smaller than the base case, and a "high" case with larger elasticities.

The top half of Table 8 shows sensitivity analysis for the demand parameters used in model calibration. The most important implication of changing these parameters is the effect on the measures of firm behavior (γ_U, γ_J, and γ_E), since differences in behavior affect firms' responses to government policies. Smaller elasticities make the goods appear more differentiated, so that firms have more potential price-setting power over their particular product. Since the data specifies a fixed markup of price over costs, firms appear more competitive in the low elasticities case, with the opposite effect for the high elasticity case. While the values of the CV's change, their ranking does not, so that US firms consistently act more competitively than their foreign rivals. Similarly, varying the demand parameters has only a very small effect on the parameter for union power, θ.

Obtaining marginal costs from an econometrically estimated cost function eliminates a major problem with the previous literature, which relies on ad-hoc estimates of marginal costs.[10] This is important because in Dixit (1988) and KHS (1990) the simulation results are most sensitive to the marginal costs, since the price-cost markup directly affects the measures of firm behavior.

The bottom part of Table 8 shows sensitivity results for the policy simulations. While varying the elasticities affects the size of the welfare gains, the main result does not change that there are much smaller welfare gains once wage-bargaining and underutilized capacity are taken into account. As before, the relevant comparison is the difference between the simulations corresponding to the top and bottom of Table 5, and the simulations corresponding to the top and bottom of Table 6. For all three sets of elasticities, when wages and costs fixed as in Table 6, taking labor rents into account gives a welfare gain about four times larger than when labor rents are ignored. In Table 5 where wages and costs are endogenous, taking labor rents into account only slightly more than doubles the welfare gains from the optimal subsidy. And for all three cases, a reduction in the union power, θ, as in Table 3, gives almost as large a welfare gain as the optimal subsidy.

7 Conclusions

The results above indicate that previous models neglect crucial aspects of import-competing manufacturing industries such as steel.

[10] As noted before, Fuss, Murphy, and Waverman (1992) independently combined a cost function with a calibrated model of competition in the automobile industry.

In particular, while taking labor rents into account gives more scope for activist policy to improve welfare, the gains to be had are far smaller than previously shown. First, the existence of underutilized capacity means that firms shift away from labor in response to protectionist policies, reducing the amount of labor rent to be captured. Second, explicitly considering the source of the rents lessens the welfare gains, since strategic union actions decrease the effectiveness of optimal policies. At the same time, the interaction of the wage-setting process and price-setting by firms means that optimal policies result in less of a reduction of prices and thus a smaller increase in consumer surplus than when wages and costs are fixed. This confirms the general point that all relevant distortions, and particularly all agents with some degree of market power, must be taken into consideration in setting policy.

Lastly, I show that there is a significant benefit from simply reducing domestic distortions such as the union wage effect. While "busting unions" should not be taken as a literal prescription for policy, it is important to note that the gains from doing so are nearly as large as the gains which result from optimal trade and industrial policies. And policies which explicitly target domestic distortions are less likely to elicit retaliatory responses from other nations.

These results suggest that actively targeting industries with labor rents should not be the primary aim of US trade policy, and that the focus on preserving "good jobs at good wages" is overstated.

References

Berndt, E., 1990. *The Practice of Econometrics: Classic and Contemporary*, particularly Chapter 9. Addison-Wesley: Reading, MA.

Binmore, K., Rubinstein, A., and Wolinsky A, 1986. "The Nash Bargaining Solution in Economic Modelling," *Rand Journal of Economics*, vol. 17, no. 2, pp. 176-88.

Brander, J. and Spencer, B., 1988. "Unionized Oligopoly and International Trade Policy," *Journal of International Economics*, vol. 24, pp. 217-234.

Brown, J. and Ashenfelter, O., 1986. "Testing the Efficiency of Employment Contracts," *Journal of Political Economy*, vol. 94, no. 3, pp. S40-S87.

Crandall, R., 1981. *The U.S. Steel Industry in Recurrent Crisis.* Brookings Institution.

Crandall, R., 1987. "The Effects of US Trade Protection for Autos and Steel." *Brookings Papers on Economic Activity*, 1987:1, pp. 271-288.

de Melo, J., and D. Tarr, 1992. *A General Equilibrium Analysis of US Foreign Trade Policy.* MIT Press: Cambridge, MA.

Dickens, W., and K. Lang, 1988. "Why It Matters What We Trade," in L. Tyson, W. Dickens, and J. Zysman (eds.), *The Dynamics of Trade and Employment*, Ballinger: Cambridge, MA.

Dixit, A., 1988. "Optimal Trade and Industrial Policy for the U. S. Automobile Industry," in R. Feenstra (ed.) *Empirical Methods for International Trade.* MIT Press: Cambridge, MA.

Eaton, J., 1988. "Comment on Dixit," in Feenstra (ed.).

Eaton, J. and G. Grossman, 1986. "Optimal Trade and Industrial Policy under Oligopoply". *Quarterly Journal of Economics*, 100, pp. 383-406.

Fuss, M., and L. Waverman, 1992. *Cost and Productivity in Automobile Production: The Challenge of Japanese Efficiency*, Cambridge University Press.

Fuss, M., S. Murphy, and L. Waverman, 1992. "The State of North American and Japanese Motor Vehicle Industries: A Partially Calibrated Model to Examine the Impacts of Trade Policy Changes," NBER Working Paper No. 4225, December.

Harrison, A., 1992. "Imperfect Explanations for Imperfect Pass-Through: Market Power and Exchange Rates in the US Steel Industry," World Bank, mimeo.

Hogan, W., 1983. *World Steel in the 1980's: A Case for Survival*, DC Heath: Lexington MA.

Katz, L. and L. Summers, 1989a. "Can Interindustry Wage Differentials Justify Strategic Trade Policy?" in R. Feenstra (ed.), *Trade Policies for International Competitiveness*, University of Chicago Press.

Katz, L. and L. Summers, 1989b. "Industry Rents: Evidence and Implications," *Brookings Papers on Economic Activity*, Microeconomics Issue, pp. 209-290.

Krishna, K., 1989. "Trade Restrictions as Facilitating Practices," *Journal of International Economics*, vol. 26, May, pp. 251-270.

Krishna, K. and M. Itoh, 1988. "Content Protection and Oligopolistic Interactions." *Review of Economic Studies*, LV, pp. 107-125.

Krishna, K., K. Hogan, and P. Swagel, 1989. "The Non-Optimality of Optimal Trade Policies: The U.S. Automobile Industry Revised, 1979-1985," NBER Working Paper No. 3118, October.

Krueger, A., and L. Summers, 1988. "Efficiency Wages and the Inter-Industry Wage Structure." *Econometrica*, vol. 56, pp. 259-294.

Lawrence, C. and R.Z. Lawrence, 1985. "Manufacturing Wage Dispersion: An End Game Interpretation." *Brookings Papers on Economic Activity*, 1:1985, pp. 47-116.

Leontief, W., 1946. "The Pure Theory of the Guaranteed Annual Wage Contract." *Journal of Political Economy*, vol. 54, pp. 76-79.

MaCurdy, T. and J. Pencavel, 1986. "Testing Between Competing Models of Wage and Employment Determination in Unionized Markets," *Journal of Political Economy*, vol. 94, no. 3, pp. S3-S39.

Matsuyama, K., 1990. "Export Subsidies as an Outcome of Management-Labor Conspiracy," *Quarterly Journal of Economics.*

McDonald, I. and R. Solow, 1981. "Wage Bargaining and Employment." *American Economic Review*, vol. 71, December, pp. 896-908.

Morrison, C., 1988. "Subequilibrium in the North American Steel Industries: A Study of Short Run Biases from Regulation and Utilisation Fluctuations," *Economic Journal*, vol. 98, June 1988, pp. 390-411.

Morrison, C., 1991. *A Microeconomic Approach to the Measurement of Economic Performance*, manuscript.

Old, B., 1985. *Competitive Status of the U.S. Steel Industry.* National Academy of Science Press Washington DC.

Oswald, A., 1985. "The Economic Theory of Trade Unions: An Introductory Survey," *Scandinavian Journal of Economics*, 87(2), pp. 160-193.

Paine Webber, 1987, 1989. *World Steel Dynamics.*

Pindyck, R., 1991. "Irreversibility, Uncertainty, and Investment," *Journal of Economic Literature*, Vol XXIX, No. 3, September, pp. 1110-1148.

Rodrik, D. (1987). "Policy Targeting with Endogenous Distortions: Theory of Optimum Subsidy Revisited," *Quarterly Journal of Economics*, pp. 903-911.

A Appendix: Demand Equations

This appendix derives the functional forms for the demands described in Section 2.1.

Let $p_U^1, \ldots, p_U^{n_U}$ denote the prices of US goods $q_U^1, \ldots, q_U^{n_U}$; let $p_J^1, \ldots, p_J^{n_J}$ denote the prices of Japanese goods $q_J^1, \ldots, q_J^{n_J}$; and let $p_E^1, \ldots, p_E^{m_E}$ denote the prices of EC goods $q_E^1, \ldots, q_E^{m_E}$. For ease of notation, let $\vec{q}_U$ denote $\{q_U^1, \ldots, q_U^{n_U}\}$, let $\vec{p}_U$ denote $\{p_U^1, \ldots, p_U^{n_U}\}$, and similarly for $\vec{q}_J$, $\vec{p}_J$, $\vec{q}_E$, and $\vec{p}_E$.

Let $C(\vec{p}_U)$ denote the marginal cost of producing the aggregate domestic good U, and $C_F(C_J, C_E)$ denote the marginal cost of producing the aggregate foreign good F. Let $C_J(\vec{p}_J)$ denote the marginal cost of the aggregate Japan good J, and $C_E(\vec{p}_E)$ denote the marginal cost of the aggregate EC good E.

Let $a_U^i(\vec{p}_U) = \partial C_U(\vec{p}_U)/\partial p_U^i$ so that $a_U^i(\cdot)$ is the unit requirement of a particular q_U^i needed to make a unit of U. The demand faced by a single US firm, q_U^i, is thus a derived demand given by:

$$q_U^i(\vec{p}_U, \vec{p}_J, \vec{p}_E) = a_U^i Q_U$$

To obtain the demand for q_U^i, then, the demand for U must be found. This is also a derived demand, as it results from the demand for steel services. If $C(C_U, C_F)$ denotes the marginal cost of services S, then $A_U(C_U, C_F) = \partial C/\partial C_U$ is the unit input requirement of U needed to make S.

If $D(C(\cdot))$ denotes the demand for S, then:

$$q_U^i(\vec{p}_U, \vec{p}_J, \vec{p}_E) = a_U^i A_U D$$

Factor demands are similarly derived from goods demands, with the unit input requirements for each factor coming from the cost function estimated in Section 2.3.

The differentiation between Japan and EC goods creates an additional level of derived demands involving the input requirements of Japan and EC goods in making up the aggregate foreign good F. Similar to US steel, let $A_F = \partial C/\partial C_F$ denote the unit-input requirement of F in steel services, S. Let $A_J(C_J, C_E) = \partial C_F/\partial C_J$, the unit input requirement of J needed to make F, and let $A_E(C_J, C_E) = \partial C_F/\partial C_E$, the unit input requirement of E in F.

As before, we can now calculate the unit input requirements of a particular q_J^i or q_E^i in J or E. Let $a_J = \partial q_J/\partial p_J^i$, the requirement for Japan firms, and $a_E = \partial q_E/\partial p_E^i$, the requirement for EC firms. Demands for q_J^i and q_E^i are then:

$$q_J^i(\vec{p}_U, \vec{p}_J, \vec{p}_E) = a_J^i A_J A_F D$$

$$q_E^i(\vec{p}_U, \vec{p}_J, \vec{p}_E) = a_E^i A_E A_F D$$

The assumption of symmetry between firms in a country combined with the production functions for U and F gives rise to the associated cost functions for the aggregate US and foreign goods:

$$C_U(\vec{p}_U) = \left[\sum_{i=1}^{n_U} \left(p_U^i\right)^{1-\sigma_U}\right]^{1/(1-\sigma_U)} = p_U n_U^{1/(1-\sigma_U)}$$

and

$$C_F(C_J, C_E) = \left(C_J^{1-\sigma_F} + C_E^{1-\sigma_F}\right)^{1/(1-\sigma_F)}$$

The cost functions for the aggregate Japan and EC goods similarly are:

$$C_J(\vec{p}_J) = \left[\sum_{i=1}^{n_J} \left(p_J^i\right)^{1-\sigma_J}\right]^{1/(1-\sigma_J)} = p_J n_J^{1/(1-\sigma_J)}$$

and

$$C_E(\vec{p}_E) = \left[\sum_{i=1}^{n_E} (p_E^i)^{1-\sigma_E}\right]^{1/(1-\sigma_E)} = p_E n_E^{1/(1-\sigma_E)}$$

Differentiating $C_U(\cdot)$ gives unit input requirements for US firms:

$$a_U^i(\cdot) = (p_U^i)^{-\sigma_u} \left[\sum_{i=1}^{n_U} (p_U^i)^{1-\sigma_U}\right]^{-1/\sigma_U} = n_U^{\sigma_U/(\sigma_U-1)}$$

Differentiating $C_F(\cdot)$ gives the unit input requirements for Japan and EC goods in the aggregate foreign good:

$$A_J = (C_J^{1-\sigma_F} + C_E^{1-\sigma_F})^{\sigma_F/(1-\sigma_F)} C_J^{-\sigma_F}$$

and

$$A_E = (C_J^{1-\sigma_F} + C_E^{1-\sigma_F})^{\sigma_F/(1-\sigma_F)} C_E^{-\sigma_F}$$

Similarly, differentiating costs $C_J(\cdot)$ and $C_E(\cdot)$ gives input requirements for each Japan and EC firm:

$$a_J^i(\vec{p}_J) = (p_J^i)^{-\sigma_J} \left[\sum_{i=1}^{n_J} (p_J^i)^{1-\sigma_J}\right]^{\sigma_J/(1-\sigma_J)} = n_J^{\sigma_J/(1-\sigma_J)}$$

and

$$a_E^i(\vec{p}_E) = (p_E^i)^{-\sigma_E} \left[\sum_{i=1}^{n_E} (p_E^i)^{1-\sigma_E}\right]^{\sigma_J/(1-\sigma_J)} = n_E^{\sigma_E/(1-\sigma_E)}$$

The production function for S gives rise to the associated cost function for steel services:

$$C(\cdot) = (C_U^{1-\sigma} + C_F^{1-\sigma})^{\frac{1}{1-\sigma}}$$

Note that $C_U(\cdot)$, $C_F(\cdot)$, $C_J(\cdot)$, and $C_E(\cdot)$ are the costs of the aggregate goods U, F, J, and E, and are thus not directly observable. The marginal cost of producing services, $C(\cdot)$, is similarly unobservable.

Differentiating $C(\cdot)$ gives the input requirements of U and F per service S:

$$\begin{aligned} A_U &= (C_U^{1-\sigma} + C_F^{1-\sigma})^{\sigma_U/(1-\sigma_U)} C_U^{-\sigma} \\ A_F &= (C_U^{1-\sigma} + C_F^{1-\sigma})^{\sigma_F/(1-\sigma_F)} C_F^{-\sigma} \end{aligned}$$

Putting the unit-input requirements together and summing over the n_U, n_J, and n_E firms gives demand equations (1), (2), and (3).

B Appendix: Elasticities of Demand

In this appendix I derive elasticities of demand for each nation's goods, taking advantage of a number of relationships implied by the CES structure of the model, along with the assumption of symmetry between the firms within each nation.

Given symmetry between the firms within each country, production shares for individual US, Japan, and EC firms equal:

$$\theta_U^i = \frac{a_U^i p_U}{C_U} = \frac{1}{n_U}$$

$$\theta_J^i = \frac{a_J^i p_J}{C_J} = \frac{1}{n_J}$$

$$\theta_E^i = \frac{a_E^i p_E}{C_E} = \frac{1}{n_E}$$

Krishna and Itoh (1988) show that aggregate domestic and foreign shares of expenditure, denoted by θ_U and θ_F, respectively, equal:

$$\begin{aligned} \theta_U &= \tfrac{A_U C_U}{C} &= \tfrac{\phi}{1+\phi} \\ \theta_F &= \tfrac{A_F C_F}{C} &= \tfrac{1}{1+\phi} \end{aligned}$$

and that price elasticities of demand for the aggregate inputs to services equal:

$$\begin{aligned} \mu_U &= -\tfrac{\partial A_U}{\partial C_U}\tfrac{C_U}{A_U} &= \tfrac{\sigma}{1+\phi} \\ \mu_U &= -\tfrac{\partial A_F}{\partial C_F}\tfrac{C_F}{A_F} &= \tfrac{\sigma\phi}{1+\phi} \end{aligned}$$

where

$$\phi = \left(\frac{C_U}{C_F}\right)^{1-\sigma}$$

Similarly, let ψ_J and ψ_E denote the expenditure shares of Japan and EC goods as a proportion of expenditure on the aggregate foreign good. These then equal:

$$\begin{aligned} \psi_J &= \tfrac{A_J C_J}{C_F} &= \tfrac{\Omega}{1+\Omega} \\ \psi_E &= \tfrac{A_E C_E}{C_F} &= \tfrac{1}{1+\Omega} \end{aligned}$$

where

$$\Omega = \left(\frac{C_J}{C_E}\right)^{1-\sigma_F}$$

These relationships considerably simplify the elasticities of demand for goods. In what follows, an elasticity such as ϵ_{ab}^{ij} denotes the elasticity of demand for the good produced by firm i in country a with respect to a change in the price of the good produced by firm j in country b.

Differentiating q_u^i gives domestic elasticities of demand:

$$\begin{aligned} \epsilon_{UU}^{ii} &= -\tfrac{\partial q_U^i}{\partial p_U^i}\tfrac{p_U^i}{q_U^i} &= \tfrac{1}{n_U}\left[\sigma_U(n_U-1)+\tfrac{\sigma+\epsilon\phi}{1+\phi}\right] \\ \epsilon_{UU}^{ij} &= \tfrac{\partial q_U^i}{\partial p_U^j}\tfrac{p_U^j}{q_U^i} &= \tfrac{1}{n_U}\left[\sigma_U-\tfrac{\sigma+\epsilon\phi}{1+\phi}\right] \\ \epsilon_{UJ}^{ij} &= \tfrac{\partial q_U^i}{\partial p_J^j}\tfrac{p_J^j}{q_U^i} &= \tfrac{1}{n_J}\left(\tfrac{\Omega}{\Omega+1}\right)\left[\tfrac{\sigma-\epsilon}{1+\phi}\right] \\ \epsilon_{UE}^{ij} &= \tfrac{\partial q_U^i}{\partial p_E^j}\tfrac{p_E^j}{q_U^i} &= \tfrac{1}{n_E}\left(\tfrac{1}{\Omega+1}\right)\left[\tfrac{\sigma-\epsilon}{1+\phi}\right] \end{aligned}$$

Differentiating q_J^i gives elasticities of demand for Japan goods:

$$\begin{aligned} \epsilon_{JJ}^{ii} &= -\tfrac{\partial q_J^i}{\partial p_J^i}\tfrac{p_J^i}{q_J^i} &= \tfrac{1}{n_J}\left[\sigma_J(n_J-1)+\sigma_F\left(1+\tfrac{\Omega}{1+\Omega}\right)+\left(\tfrac{\sigma\phi+\epsilon}{1+\phi}\right)\left(\tfrac{\Omega}{1+\Omega}\right)\right] \\ \epsilon_{JJ}^{ij} &= \tfrac{\partial q_J^i}{\partial p_J^j}\tfrac{p_J^j}{q_J^i} &= \tfrac{1}{n_J}\left[\sigma_J-\sigma_F\left(1+\tfrac{\Omega}{1+\Omega}\right)-\left(\tfrac{\sigma\phi+\epsilon}{1+\phi}\right)\left(\tfrac{\Omega}{1+\Omega}\right)\right] \\ \epsilon_{JU}^{ij} &= \tfrac{\partial q_J^i}{\partial p_U^j}\tfrac{p_U^j}{q_J^i} &= \tfrac{1}{n_U}\left[\tfrac{(\sigma-\epsilon)\phi}{1+\phi}\right] \\ \epsilon_{JE}^{ij} &= \tfrac{\partial q_J^i}{\partial p_E^j}\tfrac{p_E^j}{q_J^i} &= \tfrac{1}{n_E}\left[(\sigma_F)\left(\tfrac{1}{1+\Omega}\right)-\left(\tfrac{\sigma\phi+\epsilon}{1+\phi}\right)\left(\tfrac{1}{1+\Omega}\right)\right] \end{aligned}$$

Similarly, differentiating q_E^i gives price elasticities of demand for EC goods:

$$\begin{aligned} \epsilon_{EE}^{ii} &= -\tfrac{\partial q_E^i}{\partial p_E^i}\tfrac{p_E^i}{q_E^i} &= \tfrac{1}{n_E}\left[\sigma_E(n_E-1)+\sigma_F\left(1+\tfrac{1}{1+\Omega}\right)+\left(\tfrac{\sigma\phi+\epsilon}{1+\phi}\right)\left(\tfrac{1}{1+\Omega}\right)\right] \\ \epsilon_{EE}^{ij} &= \tfrac{\partial q_E^i}{\partial p_E^j}\tfrac{p_E^j}{q_E^i} &= \tfrac{1}{n_E}\left[\sigma_E-\sigma_F\left(1+\tfrac{1}{1+\Omega}\right)-\left(\tfrac{\sigma\phi+\epsilon}{1+\phi}\right)\left(\tfrac{1}{1+\Omega}\right)\right] \\ \epsilon_{EU}^{ij} &= \tfrac{\partial q_E^i}{\partial p_U^j}\tfrac{p_U^j}{q_E^i} &= \tfrac{1}{n_U}\left[\tfrac{(\sigma-\epsilon)\phi}{1+\phi}\right] \\ \epsilon_{EJ}^{ij} &= \tfrac{\partial q_E^i}{\partial p_J^j}\tfrac{p_J^j}{q_E^i} &= \tfrac{1}{n_J}\left[\sigma_F\left(\tfrac{\Omega}{1+\Omega}\right)-\left(\tfrac{\sigma\phi+\epsilon}{1+\phi}\right)\left(\tfrac{\Omega}{1+\Omega}\right)\right] \end{aligned}$$

The symmetry between the aggregate US good and the aggregate foreign good, and the symmetry between the aggregate Japan good and the aggregate EC good constrains ϵ^{ij}_{JU} to equal ϵ^{ij}_{EU}.

C Appendix: Bertrand and Cournot-Equivalent Behavior

In this appendix I present the equations needed to calculate Bertrand and Cournot-equivalent prices.

Bertrand-equivalent prices are calculated by setting γ^U, γ^J, and γ^E to 0, and solving the FOC's (4) - (6) simultaneously for prices p_U, p_J, and p_E. Prices affect U.S. marginal costs, c_U, and also enter the demand elasticities ϵ^{ii}_{UU}, ϵ^{ii}_{JJ}, and ϵ^{ii}_{EE}, so the system is highly nonlinear.

Cournot-equivalent prices are more difficult, because I must restrict price-setting firms' beliefs over changes in quantities. For a US firm to believe that other US firms hold output constant, it must believe that prices change such that:

$$\epsilon^{ij}_{UU}(1+(n_U-2)\gamma^{UU}) - \epsilon^{ii}_{UU}\gamma^{UU} + n_J\epsilon^{ij}_{UJ}\gamma^{UJ}\frac{p_U}{p_J} + n_E\epsilon^{ij}_{UE}\gamma^{UE}\frac{p_U}{p_E} = 0$$

For a US firm to believe that Japanese firms do not change their quantity:

$$\epsilon^{ij}_{JU}(1+(n_U-1)\gamma^{UU}) + \frac{p_U}{p_J}\gamma^{UJ}\left[\epsilon^{ij}_{JJ}(n_J-1) - \epsilon^{ii}_{JJ}\right] + \frac{p_U}{p_E}\gamma^{UE}n_E\epsilon^{ij}_{UE} = 0$$

And for a US firm to believe that EC quantity is constant:

$$\epsilon^{ij}_{EU}(1+(n_U-1)\gamma^{UU}) + \frac{p_U}{p_J}\gamma^{UJ}n_J\epsilon^{ij}_{UJ} + \frac{p_U}{p_E}\gamma^{UE}\left[\epsilon^{ij}_{EE}(n_E-1) - \epsilon^{ii}_{EE}\right] = 0$$

Three analogous equations must also hold for Japan firms, and three more for EC firms. To find the Cournot-equivalent prices, these nine equations are solved simultaneously with the three FOC's and the U.S. cost function, where p_U, p_J, and p_E, as well as the 9 component γ^{ij}'s are endogenous.

Figure 1: Timing of the Model

Government sets policies: subsidy s, tariff t

↓

Wage determined by
union-firm bargaining: wage w

↓

Firms set prices, which also
determines US costs: prices p_U, p_J, p_E
US cost c_U

↓

Steel market clears: Q_U, Q_J, Q_E

Figure 2: Demand For Steel

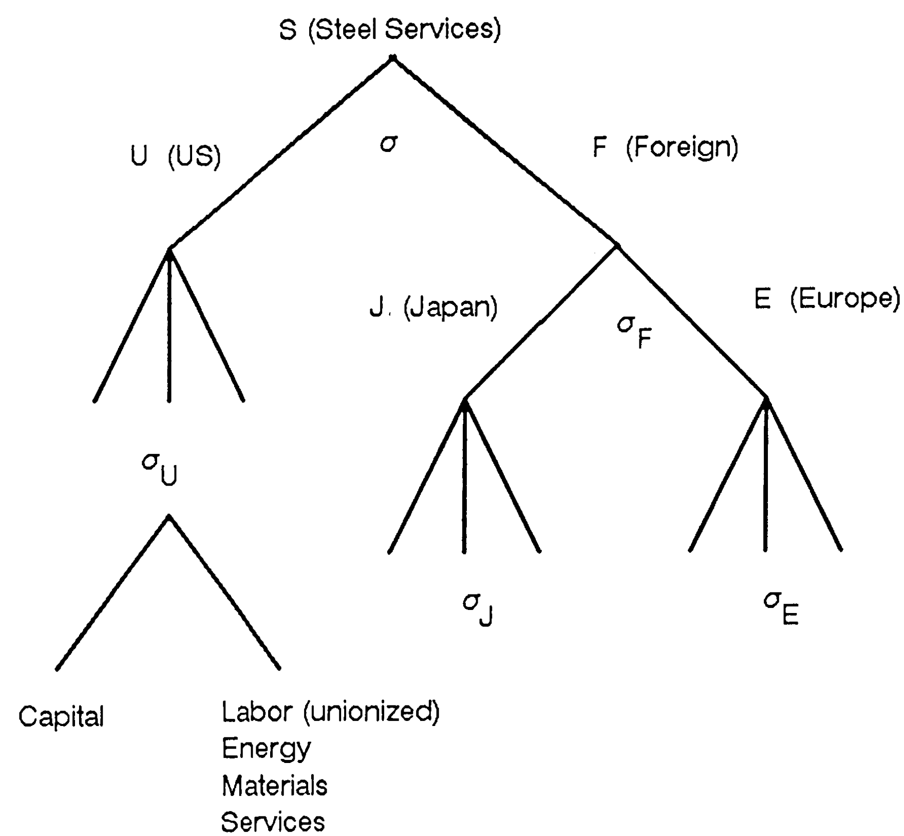

Figure 3: Cost Function for 1978

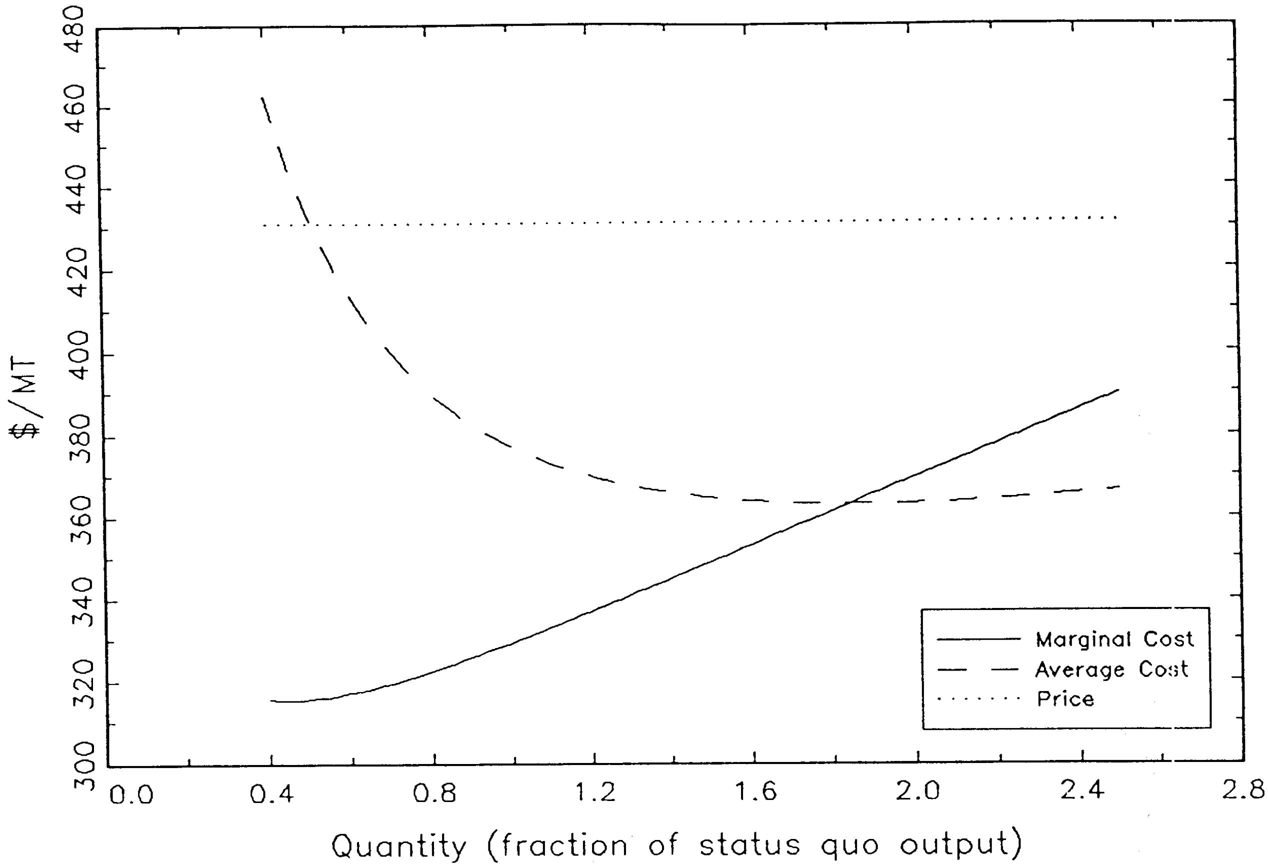

Figure 4: Capacity Utilization

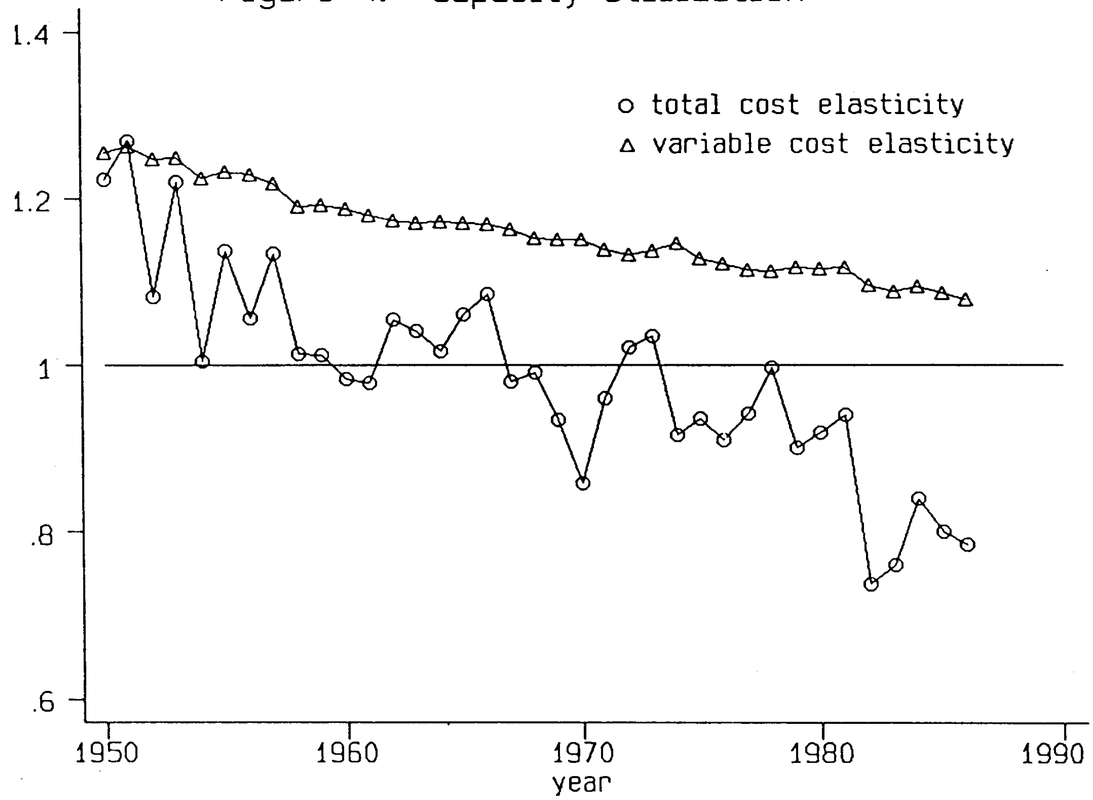

Table 1: Calibration Results

year	Demand Shift	Elasticity of Substitution		Firm Behavior (Conjectural Variations)		
	β	σ_U	σ_J	γ^U	γ^J	γ^E
1973	6.8	2.41	6.12	-2.77	2.59	3.35
1974	8.3	2.72	4.71	-2.25	-0.67	1.89
1975	6.3	2.24	4.14	-2.32	0.07	2.06
1976	6.5	2.14	3.88	-2.54	0.91	2.24
1977	7.0	2.19	5.24	-2.43	1.76	2.09
1978	7.5	2.30	6.16	-2.05	4.02	3.04
1979	7.8	2.27	5.54	-2.53	2.80	2.49
1980	6.7	2.24	4.42	-2.76	1.80	2.16
1981	6.7	2.25	4.81	-2.84	1.73	-0.40
1982	4.8	2.27	5.71	-2.41	1.83	1.79
1983	4.6	1.99	5.79	-2.91	1.21	1.69
1984	5.2	2.07	5.57	-2.97	1.78	0.54
1985	4.8	2.09	6.20	-2.25	2.87	1.71
1986	4.6	2.33	10.78	-1.59	7.75	2.93

Note: $\beta \times 10^{10}$

Table 2: Firm Behavior

year	US					Japan				EC			
	c_U	ac	p_U	p_U^B	p_U^C	c_J	p_J	p_J^B	p_J^C	c_E	p_E	p_E^B	p_E^C
1973	296	321	369	496	505	271	389	344	345	287	417	357	358
1974	330	351	417	518	531	460	575	593	600	434	561	528	529
1975	324	365	418	580	593	329	438	438	449	319	424	395	395
1976	331	377	423	615	627	273	389	368	382	299	403	372	372
1977	335	389	431	614	624	249	357	325	328	280	374	349	349
1978	329	377	431	576	584	210	384	270	271	283	401	353	354
1979	350	393	444	617	628	271	419	347	350	329	445	406	407
1980	341	384	429	606	618	282	428	373	381	323	431	400	400
1981	333	367	416	586	595	248	369	327	333	282	349	352	352
1982	312	374	398	557	566	218	310	284	285	235	313	296	297
1983	318	392	402	650	661	208	285	272	273	217	290	276	276
1984	321	380	402	619	628	186	269	246	248	208	269	265	267
1985	299	366	391	578	586	169	261	223	224	193	260	247	248
1986	287	362	388	508	515	153	277	190	191	215	307	273	274

Notes: All prices and costs are $ per metric ton, deflated to 1978 dollars

c_U, c_J, c_E marginal cost

ac average cost

p_U, p_J, p_E actual prices

p_U^B, p_J^B, p_E^B prices if firms acted Bertrand

p_U^C, p_J^C, p_E^C prices if firms acted Cournot

Table 3: Union Behavior

Union Power		Wage ($/hr)				ΔWelfare ($b)		Labor's Share of Rent			Labor Rent ($b)			US Firm Profits ($b)		
year	θ	w	$\bar{w}$	50%	max	50%	max	s.q.	50%	max	s.q.	50%	max	s.q.	50%	max
1973	0.62	12.08	6.26	8.91	18.87	1.57	-1.92	0.59	0.29	0.78	6.14	2.66	8.93	4.35	6.36	2.50
1974	0.56	12.33	5.87	8.76	20.52	1.78	-2.81	0.53	0.27	0.75	6.87	3.09	10.56	6.14	8.41	3.54
1975	0.64	12.99	5.79	8.63	18.86	1.80	-1.88	0.61	0.30	0.79	6.13	2.65	8.61	3.98	6.10	2.25
1976	0.68	13.98	5.99	8.92	18.87	1.95	-1.69	0.64	0.32	0.81	6.54	2.78	8.81	3.61	5.93	2.02
1977	0.71	14.50	6.13	9.12	18.71	2.14	-1.57	0.68	0.33	0.83	7.02	2.97	9.13	3.35	5.92	1.85
1978	0.64	14.73	6.17	9.25	20.01	2.18	-2.22	0.60	0.30	0.79	7.05	3.07	9.88	4.67	7.21	2.62
1979	0.66	14.74	6.03	9.11	19.71	2.04	-2.03	0.62	0.31	0.80	7.36	3.17	10.18	4.52	7.10	2.56
1980	0.68	15.12	5.77	8.85	19.07	1.75	-1.57	0.64	0.32	0.81	6.44	2.75	8.68	3.57	5.85	2.00
1981	0.64	15.09	5.80	8.85	19.31	1.51	-1.65	0.60	0.30	0.79	6.01	2.62	8.45	3.93	6.01	2.24
1982	0.80	17.22	5.93	8.76	16.64	1.30	-0.60	0.77	0.38	0.88	4.79	1.97	5.72	1.41	3.20	0.76
1983	0.92	16.28	6.07	8.85	15.87	1.37	-0.23	0.90	0.44	0.95	5.22	2.01	5.62	0.56	2.56	0.29
1984	0.80	15.05	6.19	9.21	17.42	1.36	-0.60	0.77	0.38	0.88	4.98	2.03	5.92	1.45	3.36	0.78
1985	0.77	15.51	6.36	9.28	17.17	1.17	-0.61	0.74	0.37	0.87	4.43	1.86	5.41	1.52	3.20	0.82
1986	0.76	16.16	6.58	9.51	17.33	1.15	-0.61	0.73	0.36	0.86	4.15	1.76	5.10	1.50	3.08	0.81

Notes:
s.q. status quo
50% 50% cut in union power, θ
max raising θ halfway to 1

Table 4: Optimal Tariff

year	tariff	ΔWelf	ΔCS	ΔProfit	ΔLR	ΔL	Δw	ΔQ_U	$\Delta price_U$
	$	$b	$b	$b	$b	%	%	%	$
Underutilized Capacity, Nash Bargaining over Wages, WITH Labor Rent									
1973	5	0.01	0.36	-0.08	-0.11	0	0	0	-1
1974	29	0.00	-0.18	0.05	0.05	0	0	0	0
1975	19	0.00	0.02	0.00	0.00	0	0	0	0
1976	7	0.00	0.28	-0.06	-0.10	0	0	0	-1
1977	7	0.01	0.37	-0.06	-0.13	0	0	0	-2
1978	-8	0.06	1.00	-0.22	-0.31	0	-2	-2	-4
1979	3	0.01	0.42	-0.09	-0.13	0	0	0	-2
1980	2	0.01	0.37	-0.07	-0.12	0	-1	0	-2
1981	10	0.00	0.24	-0.05	-0.07	0	0	0	-1
1982	5	0.01	0.32	-0.04	-0.13	0	-1	0	-2
1983	2	0.02	0.33	-0.02	-0.15	0	-2	0	-2
1984	2	0.03	0.50	-0.06	-0.19	0	-2	-1	-3
1985	4	0.02	0.43	-0.06	-0.16	0	-2	-1	-2
1986	-2	0.04	0.56	-0.08	-0.22	0	-3	-2	-3
Costs Fixed, Wages Fixed, WITH Labor Rent									
1973	42	0.02	-0.30	0.07	0.09	1	-	1	0
1974	91	0.12	-0.83	0.23	0.24	4	-	4	0
1975	60	0.04	-0.40	0.10	0.13	2	-	2	0
1976	43	0.02	-0.29	0.06	0.10	1	-	1	0
1977	39	0.02	-0.31	0.06	0.10	1	-	1	0
1978	25	0.00	-0.10	0.02	0.03	0	-	0	0
1979	40	0.02	-0.28	0.06	0.09	1	-	1	0
1980	40	0.01	-0.24	0.05	0.08	1	-	1	0
1981	41	0.02	-0.30	0.06	0.09	1	-	1	0
1982	28	0.00	-0.10	0.01	0.03	0	-	0	0
1983	24	0.00	-0.04	0.00	0.02	0	-	0	0
1984	22	0.00	-0.03	0.00	0.01	0	-	0	0
1985	18	0.00	0.03	0.00	-0.01	0	-	0	0
1986	10	0.00	0.16	-0.02	-0.05	-1	-	-1	0

Notes: t — tariff; Welf — Welfare; CS — Consumers Surplus; LR — Labor Rent; L — Labor (hours); w — wage ($/hr); Q_U — Quantity of US Steel

Table 5: Optimal Subsidy
Underutilized Capacity

year	s	ΔWelf	ΔCS	ΔProfit	ΔLR	ΔL	Δw	ΔQ_U	$\Delta price_U$	
	$	$b	$b	$b	$b	%	%	%	%	$
Nash Bargaining over Wages, WITH Labor Rent										
1973	102	2.10	10.08	2.37	3.22	27	11	44	-24.9	-92
1974	117	2.66	11.80	3.32	3.60	29	10	46	-25.1	-105
1975	121	2.46	10.74	2.24	3.34	30	11	51	-27.8	-116
1976	120	2.40	10.89	2.03	3.55	27	12	49	-27.2	-114
1977	123	2.60	11.56	2.01	4.05	27	14	50	-26.9	-117
1978	123	3.04	12.94	2.62	3.83	30	11	52	-28.1	-121
1979	122	2.63	12.26	2.40	3.78	26	12	46	-25.9	-115
1980	116	2.09	10.17	1.89	3.29	24	13	44	-25.0	-107
1981	110	1.94	9.67	2.01	2.99	24	12	42	-24.2	-100
1982	110	1.62	7.52	0.89	2.87	23	17	48	-26.4	-105
1983	109	1.47	7.29	0.37	3.20	19	21	44	-25.5	-102
1984	102	1.40	7.25	0.83	2.71	19	17	41	-23.5	-95
1985	106	1.72	7.91	0.93	2.59	24	16	50	-27.4	-107
1986	109	1.99	8.49	0.95	2.53	27	15	58	-30.4	-118
Wages Fixed, NO Labor Rent										
1973	59	0.79	6.11	1.53	-	18	-	26	-16.1	-59
1974	71	1.03	7.42	2.15	-	20	-	28	-16.9	-70
1975	74	1.00	6.82	1.55	-	20	-	31	-18.9	-79
1976	73	0.99	6.98	1.50	-	19	-	30	-18.5	-78
1977	75	1.09	7.52	1.60	-	20	-	31	-18.9	-81
1978	79	1.35	8.63	1.94	-	21	-	34	-20.0	-86
1979	76	1.10	8.03	1.79	-	19	-	29	-18.0	-80
1980	71	0.86	6.61	1.45	-	17	-	27	-17.3	-74
1981	67	0.80	6.22	1.48	-	17	-	26	-16.5	-69
1982	68	0.71	5.08	0.94	-	18	-	31	-18.9	-75
1983	66	0.65	5.02	0.74	-	17	-	29	-18.5	-74
1984	64	0.65	5.05	0.95	-	16	-	28	-17.2	-69
1985	70	0.85	5.61	0.99	-	19	-	34	-20.5	-80
1986	76	1.05	6.25	1.03	-	22	-	41	-23.7	-92

Notes: s subsidy; Welf Welfare; CS Consumers Surplus; LR Labor Rent; L Labor (hours); w wage ($/hr); Q_U Quantity of US Steel

Table 6: Optimal Subsidy
Costs Fixed

year	s	ΔWelf	ΔCS	ΔProfit	ΔLR	ΔL	Δ	ΔQ_U	$\Delta price_U$	
	$	$b	$b	$b	$b	%	%	%	%	$
WITH Labor Rent										
1973	112	4.28	17.17	0.87	4.99	81	-	81	-37.8	-139
1974	127	5.31	20.34	1.24	5.94	86	-	86	-38.4	-160
1975	135	5.08	18.23	1.00	5.81	95	-	95	-41.6	-174
1976	137	5.19	18.99	1.00	6.10	93	-	93	-41.4	-175
1977	142	5.80	20.63	1.18	6.96	99	-	99	-42.3	-182
1978	140	6.29	22.28	1.34	7.01	99	-	99	-42.4	-183
1979	140	5.63	21.42	1.10	6.47	88	-	88	-40.0	-178
1980	134	4.65	18.01	0.88	5.47	85	-	85	-39.2	-168
1981	125	4.22	16.86	0.86	4.81	80	-	80	-37.5	-156
1982	131	3.84	13.74	0.75	4.66	97	-	97	-42.0	-167
1983	135	3.86	14.03	0.62	4.94	95	-	95	-42.4	-170
1984	125	3.55	13.71	0.71	4.24	85	-	85	-38.9	-156
1985	126	3.86	13.85	0.82	4.31	97	-	97	-42.0	-165
1986	128	4.22	14.19	0.90	4.48	108	-	108	-44.6	-173
NO Labor Rent										
1973	57	0.95	7.47	0.44	-	32	-	32	-19.2	-71
1974	68	1.28	9.31	0.66	-	36	-	36	-20.5	-86
1975	72	1.18	8.21	0.52	-	38	-	38	-22.2	-93
1976	71	1.15	8.28	0.51	-	36	-	36	-21.4	-91
1977	73	1.26	8.84	0.60	-	37	-	37	-21.7	-94
1978	77	1.57	10.34	0.73	-	41	-	41	-23.3	-101
1979	73	1.30	9.48	0.56	-	35	-	35	-20.8	-93
1980	68	1.01	7.76	0.44	-	33	-	33	-19.9	-85
1981	65	0.96	7.53	0.44	-	32	-	32	-19.5	-81
1982	66	0.80	5.77	0.37	-	36	-	36	-21.1	-84
1983	65	0.71	5.61	0.29	-	33	-	33	-20.4	-82
1984	63	0.74	5.86	0.35	-	33	-	33	-19.6	-79
1985	69	0.95	6.41	0.44	-	40	-	40	-23.0	-90
1986	74	1.15	6.92	0.51	-	46	-	46	-25.8	-100

Notes:

s	subsidy	Welf	Welfare	CS	Consumers Surplus
LR	Labor Rent	L	Labor (hours)	w	wage ($/hr)
Q_U	Quantity of US Steel				

Table 7: Optimal Subsidy
Underutilized Capacity and "Efficiency Wages"

year	s	ΔWelf	ΔCS	ΔProfit	ΔLR	ΔL	Δw	ΔQ_U	$\Delta price_U$	
	$	$b	$b	$b	$b	%	%	%	%	$
Wages Fixed, WITH Labor Rent										
1973	98	2.32	10.68	2.96	1.99	32	-	47	-26.1	-96
1974	114	2.88	12.52	3.97	2.38	35	-	50	-26.3	-110
1975	118	2.70	11.49	2.90	2.19	36	-	55	-29.3	-123
1976	117	2.71	11.82	2.83	2.22	34	-	53	-28.8	-122
1977	119	2.98	12.63	2.98	2.43	35	-	56	-29.1	-126
1978	120	3.34	13.82	3.41	2.50	35	-	56	-29.6	-128
1979	120	2.95	13.34	3.29	2.36	32	-	50	-27.7	-123
1980	113	2.39	11.06	2.69	1.96	30	-	48	-26.8	-115
1981	107	2.19	10.41	2.71	1.77	29	-	46	-25.7	-107
1982	106	1.91	8.38	1.71	1.52	32	-	54	-28.8	-115
1983	106	1.85	8.54	1.44	1.55	30	-	52	-29.0	-117
1984	101	1.74	8.39	1.74	1.39	28	-	48	-26.5	-107
1985	103	1.97	8.70	1.69	1.38	31	-	56	-29.6	-116
1986	105	2.20	9.08	1.62	1.39	34	-	63	-32.1	-124

Notes:

s	subsidy	Welf	Welfare	CS	Consumers Surplus
LR	Labor Rent	L	Labor (hours)	w	wage ($/hr)
Q_U	Quantity of US Steel				

Table 8: Sensitivity Analysis for 1978

MODEL PARAMETERS

Elasticities	σ^*	σ_U	σ_F^*	σ_J	σ_E^*
low	2.00	1.70	3.00	4.52	5.00
base	3.05	2.30	5.00	6.16	7.00
high	5.00	3.11	7.00	8.01	9.00
	ϵ^*	γ^U	γ^J	γ^E	θ
low	1.01	-2.60	2.13	0.94	0.644
base	1.10	-2.05	4.02	3.04	0.643
high	1.50	-1.27	6.14	5.16	0.643

Note: * = assumed parameter

OPTIMAL POLICY SIMULATIONS

Assumptions for Wages and Costs	Elasticities	Subsidy $	ΔWelfare $b	ΔLabor %	ΔWage %	ΔQ_U %	Δp_U %
Table 3: 50% cut in θ, parameter for union power	low	0	2.015	20.2	-37.7	12.0	-9.6
	base	0	2.182	21.1	-37.2	13.6	-9.2
	high	0	2.635	23.3	-36.1	17.5	-8.3
Table 5, top: Wage-bargaining and underutilized capacity, with labor rent	low	121	2.760	27.6	6.9	47.1	-29.3
	base	123	3.036	29.6	11.1	52.4	-28.1
	high	131	3.836	35.5	22.9	67.7	-25.5
Table 5, bottom: Wages fixed and underutilized capacity, no labor rent	low	79	1.188	18.6	-	29.4	-20.5
	base	79	1.345	21.2	-	33.5	-20.0
	high	81	1.844	28.9	-	45.9	-19.0
Table 6, top: Wages and costs fixed, with labor rent	low	139	5.363	83.3	-	83.3	-42.2
	base	140	6.290	99.3	-	99.3	-42.4
	high	140	9.453	152.4	-	152.4	-42.3
Table 6, bottom: Wages and costs fixed, no labor rent	low	77	1.355	34.6	-	34.6	-23.4
	base	77	1.571	40.8	-	40.8	-23.3
	high	77	2.304	59.6	-	59.6	-23.2

International Finance Discussion Papers

Please address requests for copies to International Finance Discussion Papers, Division of International Finance, Stop 24, Board of Governors of the Federal Reserve System, Washington, D.C. 20551.

International Finance Discussion Papers

IFDP Number	Titles	Author(s)
	1993	
446	Market Share and Exchange Rate Pass-Through in World Automobile Trade	Robert C. Feenstra Joseph E. Gagnon Michael M. Knetter
445	Industry Restructuring and Export Performance: Evidence on the Transition in Hungary	Valerie J. Chang Catherine L. Mann
444	Exchange Rates and Foreign Direct Investment: A Note	Guy V.G. Stevens
443	Global versus Country-Specific Productivity Shocks and the Current Account	Reuven Glick Kenneth Rogoff
442	The GATT's Contribution to Economic Recovery in Post-War Western Europe	Douglas A. Irwin
441	A Utility Based Comparison of Some Models of Exchange Rate Volatility	Kenneth D. West Hali J. Edison Dongchul Cho
440	Cointegration Tests in the Presence of Structural Breaks	Julia Campos Neil R. Ericsson David F. Hendry
	1992	
439	Life Expectancy of International Cartels: An Empirical Analysis	Jaime Marquez
438	Daily Bundesbank and Federal Reserve Intervention and the Conditional Variance Tale in DM/$-Returns	Geert J. Almekinders Sylvester C.W. Eijffinger
437	War and Peace: Recovering the Market's Probability Distribution of Crude Oil Futures Prices During the Gulf Crisis	William R. Melick Charles P. Thomas
436	Growth, Political Instability, and the Defense Burden	Stephen Brock Blomberg
435	Foreign Exchange Policy, Monetary Policy, and Capital Market Liberalization in Korea	Deborah J. Lindner
434	The Political Economy of the Won: U.S.-Korean Bilateral Negotiations on Exchange Rates	Deborah J. Lindner
433	Import Demand and Supply with Relatively Few Theoretical or Empirical Puzzles	Andrew M. Warner