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Chapter Author: Kala Krishna, Kathleen Hogan, Phillip Swagel

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1 The Nonoptimality of Optimal Trade Policies: The U.S. Automobile Industry Revisited, 1979–1985

Kala Krishna, Kathleen Hogan, and Phillip Swagel

1.1 Introduction

A central theme of recent work on trade policy for imperfectly competitive markets has been that by precommitting to tariffs or subsidies, governments can affect firms' strategic positions, thereby shifting profits toward domestic firms.[1] Eaton and Grossman (1986) show, however, that the form of optimal trade policies depends critically on the nature of the competition between firms.[2] Hence, if such models are to be used to justify activist trade policy, it is necessary to have information not only on demand and cost conditions, but also on the nature of the competition between rival firms.

There has recently been some success in implementing these theories using calibration models. Dixit (1988) applies a calibrated model to U.S.-Japan competition in the automobile industry. He uses a conjectural variations (CV) approach to capture firm interactions, where the conjectures result from use of profit maximization equations calibrated to market data. The CVs then combine with calibrated estimates of demand to determine the optimal trade and industrial policies.

This work has generated excitement both in policy circles and among econo-

Kala Krishna is professor of economics at Pennsylvania State University and a research associate of the National Bureau of Economic Research. Kathleen Hogan is the senior technical marketing manager at Oracle Corporation. Phillip Swagel is an economist at the Board of Governors of the Federal Reserve System.

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1. See Dixit (1988) for a survey of this literature.

2. Optimal policy, of course, depends on what other distortions exist. See Krishna and Thursby (1989), who look at overall optimal policies using a targeting approach.

mists, as policy recommendations can be made even when only minimal data is available.[3] Richardson (1989), Srinivasan (1989), and Helpman and Krugman (1989) survey work in this area. Applied econometricians, however, look upon these models with considerable suspicion, because they appear to elicit policy recommendations out of tiny data sets and often poorly known elasticity parameters. Sensitivity analysis is typically limited to simply examining the effects of changing the parameters used in calibration.

In this paper, we explore the robustness of such models to changes in model specification itself. Since Dixit's model (1988) is probably the most influential of these models to date, we examine how an alternative specification of this model alters the policy recommendations and welfare results of the calibration exercise. As does Dixit, we apply the model to U.S.-Japan competition in the automobile industry, expanding the years examined to the full range from 1979 to 1985. The specification we employ is richer than Dixit's in that we allow product differentiation not only between U.S. and Japanese goods, but also between goods made within each of the countries.[4]

The advantages of doing so are twofold. First, the richer specification allows us to get estimates for the extent of product differentiation, as well as time-varying behavioral parameters for firms and consumers. Second, it allows us to ask which results from Dixit's simpler model are robust and which are artifacts of the model specification.

The effect of the richer specification is to completely reverse the sign of the resulting optimal trade policy: we find the optimal policy to be a subsidy to rather than a tax on imports. In fact, following the policies recommended by Dixit's model can result in a welfare loss if the "true" model is as we specify. The more detailed specification also greatly affects the implicit estimates of collusion/competition between firms. Our results suggest that auto industry firms behave more competitively than Bertrand oligopolists, as opposed to Dixit's finding of competition somewhere between that of Bertrand and Cournot oligopolists. Dixit's result is in part a byproduct of his assumption that firms within a nation produce a homogeneous good. With this assumption, the existence of any markup of price above marginal cost implies that behavior is more collusive than Bertrand.

On the other hand, some results are robust. For example, the effects on firms' behavior of trade policies, particularly the voluntary export restraints (VERs) imposed at the end of 1981, correspond to the effects noted by Dixit. Our implicit estimates of demand cross-elasticities are also consistent with

3. Other examples of work in this area include that of Baldwin and Krugman (1988) and Venables and Smith (1986).

4. Dixit (1988), in contrast, assumes that goods produced within a country are perfect substitutes for one another—that a Chevrolet is the same as a Lincoln or a Pontiac. Although our specification allows for imperfect substitution between all products, the separability we impose groups together all U.S. cars and all Japanese cars. That is, our model puts a Chevy in the same group as a Cadillac, and a Civic in the same group as an Acura.

other sources. In addition, the targeting of instruments to distortions evident in Dixit's results seems to carry through. Finally, as is common with most calibrated trade models, the extent of welfare gains from optimal policies, particularly optimal trade policies alone, remains quite limited.

In section 1.2, we develop the model, present the data and sources, and explain the calibration procedure. Section 1.3 contains our results. We examine the years from 1979 to 1985, which includes years when VERs were in force. Krishna (1989) shows that in the presence of such restraints the behavior of firms is likely to become more collusive as foreign firms become effectively capacity-constrained. The results in Dixit (1988) are consistent with this. Dixit looks at the years 1979, 1980. and 1983. The behavior he finds in 1983 appears more collusive than that in 1980. Our results in section 1.3.1 similarly indicate that VERs allowed Japanese firms to act more collusively from 1981 to 1983. After 1983, however, we find that both U.S. and Japanese firms acted less competitively than prior to the VERs.

In section 1.3.2 we derive the welfare function, which we then maximize to obtain the optimal tariff and production subsidy. As in Dixit (1988), we estimate optimal polices both with and without monopoly (union) labor rents. We then compare our results to Dixit's. Dixit finds that the optimal policy consists of a tariff on imports and a subsidy to domestic production. In contrast, our model indicates a subsidy to both imports and domestic production to be optimal. We suspect that this is related to our demand specification, which increases the importance of consumer surplus in welfare, thereby increasing the attractiveness of import subsidies which raise consumption. In addition, competition in our model appears to be quite vigorous.[5] This tends to limit the gains from using the optimal production subsidy, as these gains are largest in the face of less competitive behavior. As does Dixit, we find that the existence of labor rents raises the optimal subsidy to production and reduces, and in some cases reverses, the optimal import subsidy.

The final section offers some concluding comments and directions for future research. Our work indicates that there is good reason to be suspicious of the results of such simple calibration exercises. Indeed, policymakers should be extremely cautious in the application of "optimal" trade policies suggested by calibrated models, as the nature of the recommended policies may simply be an artifact of the model specification and calibration procedure. Since the optimal policy resulting from one model can differ dramatically from that of another model, and since use of the "wrong" policies can actually reduce welfare, it is important to specify a flexible form which does not dictate the direction of the results. Even if the optimal policies are found and implemented, the gains from

5. The direction of optimal trade policy is known to be related to the extent of competition, as parametrized by the choice of the strategic variable and thus in our model by the CVs. For example, in Eaton and Grossman's (1986) simple model of duopolistic competition in third party markets, a tax on exports turns out to be optimal with price competition, while a subsidy is optimal with quantity competition.

doing so are relatively limited, even without foreign retaliation. This result, that only fairly small welfare gains are to be had from optimal tariffs and subsidies, seems common to many such models.

Calibration models should thus probably not be used to determine trade and industrial policy without detailed empirical work to guide the model selection. Sufficiently well specified, however, they prove to be a valuable tool in the analysis of imperfectly competitive industries, since many important results are not sensitive to model specification. Guidance from careful empirical work as to the correct demand and cost parametrizations to use in such calibration models is vital for them to serve as useful guides to determine trade policy.

1.2 A Model with Product Differentiation

We extend Dixit (1988) by allowing for product differentiation among home and foreign firms, as opposed to Dixit's assumption that all firms in a country produce the same good. This is important, since Dixit's results, which suggest that behavior lies between Cournot and Bertrand, could be a result of this assumption. With homogeneous goods and many firms, any markup over cost implies behavior more collusive than that of Bertrand oligopolists. The richer specification allows changes in the parametrization to affect not only the magnitude of the optimal tariff, but also the sign. In contrast, Dixit's parametrization restricts tariffs and subsidies to be positive.[6]

1.2.1 The Model

Demand raises from an aggregate consumer who receives all profits and tariff revenues and maximizes a utility function of the form:

$$u = n_0 + U(S),$$

where n_0 is a numeraire good, and $U(S)$ is the subutility function,

$$U(S) = \beta S^{\alpha},$$

with

$$S = \left(\left[\sum_{i=1}^{n} (x^i)^{\rho_x} \right]^{\rho/\rho_x} + \left[\sum_{i=1}^{m} (y^i)^{\rho_y} \right]^{\rho/\rho_y} \right)^{1/\rho}.$$

This form allows ρ to parametrize the extent of product differentiation between U.S. goods x and Japanese goods y, while ρ_x and ρ_y parametrize substitution within home goods and within foreign goods, respectively.[7]

6. In Dixit's model, welfare increases with a subsidy or a tariff from an initial position of zero tariffs and subsidies. With a well-behaved welfare function this implies that the optimal tariff and subsidy is positive.

7. Anderson, De Palma, and Thisse (1989) show that these CES demands can arise from the aggregation of consumers with Lancasterian preferences over characteristics. The key restriction needed is that the number of characteristics exceeds the number of varieties (models) minus one.

To best understand the form of the demand functions, think of this subutility function as a particular separable form, and think of β as a scale parameter. To derive the demand functions for the goods, think of S as the level of services produced by all new cars purchased, both domestic and foreign.

Consumers purchase U.S. cars x^i from each of the n domestic firms and Japanese cars y^i from the m foreign firms. The goods of the individual firms are then used to make the aggregate goods X and Y. These X and Y in turn make the services S from which consumers derive utility. Since consumers produce the services using a household production function, the price of a service equals its marginal cost. Firms' market power, of course, creates a wedge between the price and marginal cost of the products from which the services are produced.

The actual forms of these functions can be obtained from the CES parametrization. Equating the marginal utility of S with its marginal cost C and inverting gives the demand for services:

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

The production functions for X and Y give rise to the associated cost functions:

$$p(v^1, \ldots, v^n) = \left[\sum_{i=1}^{n} (v^i)^{r_x}\right]^{1/r_x}$$

and

$$q(w^1, \ldots, w^m) = \left[\sum_{i=1}^{m} (w^i)^{r_y}\right]^{1/r^y},$$

where v denotes U.S. price, w Japanese price, and $r_x = \rho_x/(\rho_x - 1)$ and $r_y = \rho_y/(\rho_y - 1)$.

These cost functions can then be differentiated to obtain the unit input requirements for the output of individual firms in the aggregate goods X and Y, while the cost function for services, $C(p(\cdot),q(\cdot))$, can be differentiated to obtain the input requirements of X and Y in services S, which we denote as a and a^*.

To calibrate the model, assume that firms within each country are symmetric, and then use the CES structure to obtain the demands for individual U.S. and Japanese firms' goods, $x^i(\cdot)$ and $y^i(\cdot)$:

$$x^i = \frac{n^{(1-r_x)/r_x}}{(\alpha\beta)^{1/(\alpha-1)}} (vn^{1/r_x})^{r-1} (v^r n^{r/r_x} + w^r m^{r/r_y})^{((\alpha-1)(1-r)+1)/(\alpha-1)r},$$

and

$$y^i = \frac{m^{(1-r_y)/r_y}}{(\alpha\beta)^{1/(\alpha-1)}} (wm^{1/r_y})^{r-1} (v^r n^{r/r_x} + w^r m^{r/r_y})^{((\alpha-1)(1-r)+1)/(\alpha-1)r},$$

Note that $x^i(\cdot)$ and $y^i(\cdot)$ thus depend on the variables n, m, v, w, r, r_x, r_y, α, and β, where n and m, the number of domestic and foreign firms, and v and w, domestic and foreign prices, are taken from the data. From the cost function for services, C, $r = \rho/(\rho - 1)$.

Summing these demands over the n domestic firms and m foreign firms gives the demands for U.S. and Japanese autos. Since we assume that both markets clear, these demands are observable as actual sales, which we denote as Q_1 for U.S. cars and Q_2 for Japanese cars:

$$(1) \qquad Q_1 = \frac{n^{1/r_x}}{(\alpha\beta)^{1/(\alpha-1)}} (vn^{1/r_x})^{r-1} (v^r n^{r/r_x} + w^r m^{r/r_y})^{((\alpha-1)(1-r)+1)/(\alpha-1)r},$$

$$(2) \qquad Q_2 = \frac{m^{1/r_y}}{(\alpha\beta)^{1/(\alpha-1)}} (wm^{1/r_y})^{r-1} (v^r n^{r/r_x} + w^r m^{r/r_y})^{((\alpha-1)(1-r)+1)/(\alpha-1)r}.$$

Before we derive the remaining equations for the calibration, recall that the elasticity of substitution between domestic and foreign goods equals

$$\sigma = \frac{1}{1 - \rho} = 1 - r,$$

which is defined so as to be positive. The analogous σ_x and σ_y parametrize the degree of substitutability between goods produced by two firms of the same nationality, with

$$\sigma_x = 1 - r_x,$$

and

$$\sigma_y = 1 - r_y.$$

The demand elasticity for the aggregate good, ε, defined so as to be positive, equals

$$\varepsilon = -\frac{\partial D(C(\cdot))}{\partial C(\cdot)} \frac{C(\cdot)}{D(\cdot)} = \frac{1}{1 - \alpha}.$$

We next use a number of relationships implied by the CES structures to derive price elasticities of demand. We then use these elasticities, along with the demand functions for each good, to derive expressions for firms' profit maximizing conditions.[8]

Differentiating $x^i(\cdot)$ gives domestic elasticities of demand:

$$\varepsilon^{ii}(x,x) = -\frac{\partial x^i}{\partial v^i} \frac{v^i}{x^i} = \frac{1}{n}\left[(1 - r_x)(n - 1) + \frac{1 - r + \varepsilon\phi}{1 + \phi}\right],$$

and

8. Krishna, Hogan, and Swagel (1989) contains a fuller derivation of these elasticities.

$$\varepsilon^{ij}(x,x) = \frac{\partial x^i}{\partial v^j}\frac{v^j}{x^i} = \frac{1}{n}\left[(1 - r_x) - \frac{1 - r + \varepsilon\phi}{1 + \phi}\right],$$

where

$$\phi = \left(\frac{p}{q}\right)^r.$$

Similarly, differentiating $y^i(\cdot)$ gives foreign elasticities of demand:

$$\varepsilon^{ii}(y,y) = -\frac{\partial y^i}{\partial w^i}\frac{w^i}{y^i} = \frac{1}{m}\left[(1 - r_y)(m - 1) + \frac{(1 - r)\phi + \varepsilon}{1 + \phi}\right],$$

and

$$\varepsilon^{ij}(y,y) = \frac{\partial y^i}{\partial w^j}\frac{w^j}{y^i} = \frac{1}{m}\left[(1 - r_y) - \frac{(1 - r)\phi + \varepsilon}{1 + \phi}\right].$$

Note that $\varepsilon^{ij}(a,b)$ is the elasticity of demand for the ith good in country a with respect to the price of the jth good in country b. For example, $\varepsilon^{ii}(x,x)$ denotes domestic firms' own elasticity of demand, while $\varepsilon^{ij}(y,y)$ represents foreign firms' cross-elasticity of demand when both i and j are foreign goods. Similarly, cross-elasticities of demand between the goods of different countries equal

$$\varepsilon^{ij}(x,y) = \frac{\partial x^i}{\partial w^j}\frac{w^j}{\partial x^i} = \frac{1}{m}\left[\frac{1 - r - \varepsilon}{1 + \phi}\right],$$

and

$$\varepsilon^{ij}(y,x) = \frac{\partial y^i}{\partial v^j}\frac{v^j}{\partial y^i} = \frac{1}{n}\left[\frac{(1 - r - \varepsilon)\phi}{1 + \phi}\right].$$

We are now ready to use firms' first-order conditions for profit maximization. The profits of a typical U.S. firm are

$$\pi^i = (v^i - d + s)x^i(v^1, \ldots, v^n, w^1, \ldots, w^m),$$

where s is the specific subsidy to home firms and d is the (constant) domestic marginal cost of production.

This yields the first-order condition for a U.S. firm:

(3) $$\varepsilon^{ii}(x,x) - \gamma = v^i/(v^i - d + s),$$

with the cv,

$$\gamma = (n - 1)\varepsilon^{ij}(x,x)\gamma^{11} + m\varepsilon^{ij}(x,y)\frac{v}{w}\gamma^{12},$$

where

$$\gamma^{11} = \frac{\partial v^j}{\partial v^i},$$
$$\gamma^{12} = \frac{\partial w^j}{\partial v^i}.$$

Similarly, the first-order condition for a Japanese firm is:

$$\varepsilon^{ii}(y,y) - \gamma^* = w^i/(w^i - d^* - t), \tag{4}$$

where t is the specific tariff on the foreign firm and d^* is the (constant) foreign marginal cost of production. The foreign cv is thus

$$\gamma^* = n\varepsilon^{ij}(y,x)\frac{w}{v}\gamma^{21} + (m - 1)\varepsilon^{ij}(y,y)\gamma^{22},$$

where

$$\gamma^{21} = \frac{\partial v^j}{\partial w^i},$$
$$\gamma^{22} = \frac{\partial w^j}{\partial w^i}.$$

We now have four equations, but seven unknowns: γ, γ^*, α, β, r, r_x, and r_y. There are many possible ways to complete the calibration; available elasticity estimates typically determine the route chosen. Since Dixit cites several estimates for ε, the total elasticity of demand for all automobiles, and σ, the elasticity of substitution between U.S. and Japanese cars, we employ these in the calibration. Following Dixit, we take 2.0 as the base case for σ and perform sensitivity analysis using values of 1.5 and 3.0. For ε, Dixit's figure of 1.0 would imply $\alpha = 0$. We therefore use 1.1 as our central case and perform sensitivity analysis for values of 1.05, 1.30, and 1.50.[9] Table 1.9 contains the results of this sensitivity analysis, which we describe in section 1.3.4. For U.S. and Japanese cars to be substitutes, e.g., $\varepsilon^{ij}(x,y) > 0$, ε must be less than σ, so we report no results for the case where both ε and σ equal 1.50.

Given data for v, w, n, m, Q_1, and Q_2 and estimates for ε and σ, the demand equations (1) and (2) become a system of two equations with the three unknowns β, σ_x, and σ_y. We solve the system recursively. Dividing (1) by (2) eliminates β. Taking a value for σ_y as given then gives σ_x. Substituting σ_x into (1) or σ_y into (2) gives β.

Since Japanese cars are probably closer substitutes for one another than they are for U.S. cars, σ_y should be larger than σ. We take σ_y as 3.0 for our central case; this is larger than the central case estimate for σ of 2.10.[10] As described in section 1.3.4, table 1.10 shows the effects of changing σ_y on firms' implied

9. Further evidence is provided by De Melo and Tarr (1990), who take the price elasticity of demand to be 1.1 for U.S. cars and 1.2 for foreign cars.

10. While this value for σ_y might seem arbitrary, the choice of σ_y does not at all affect the resulting prices, welfare, or optimal policies. A proof of this is available from the authors.

conduct. In general, a larger σ_y implies that Japanese firms act more collusively, since they persist in charging a price above marginal cost even as their products become less distinguishable. The effect on the implied conduct of U.S. firms is small.

Given σ_x and σ_y, we can calculate ϕ as $(p/q)^r$. Another way to get ϕ would be to use the result of Krishna and Itoh (1988) that $\theta = \phi/(1 + \phi)$, where θ is domestic producers' share in expenditure, which equals ap/C. Thus, using the data described below to find θ determines the value of ϕ. The calibration procedure ensures that both methods produce the same ϕ. Once we know ϕ, r, ε, r_x, and r_y, the first-order conditions (3) and (4) provide γ and γ^*.

These aggregate CVs can in turn be decomposed into the component γ^{ij}s using the definitions of γ and γ^* given above. Since there are four γ^{ij}s and only two equations that define them, we must set either $\gamma^{11} = \gamma^{12}$ and $\gamma^{21} = \gamma^{22}$, or set $\gamma^{11} = \gamma^{22}$ and $\gamma^{12} = \gamma^{21}$. The first set of restrictions implies that firms have the same conjectures about both domestic competitors and foreign firms. As demonstrated in Krishna (1989), this is not a good idea for years with VERs. The second set of restrictions implies that domestic firms' conjectures about other domestic firms is the same as the foreign firms' conjectures about other foreign firms and, similarly, that each nation's firms hold identical conjectures about firms in the other nation. U.S. and Japanese firms are thus required to behave similarly, which again may not be true. Since neither set of restrictions is particularly appealing, we simply use the aggregate CVs γ and γ^* in our simulations.[11]

1.2.2 Data

Table 1.1 contains our data. Prices and quantities for both U.S. and Japanese cars are taken from the *Automotive News Market Data Book* (*ANMDB*). Prices are calculated as a weighted average of the suggested retail prices for March or April of each year, exclusive of optional equipment and domestic transport costs, with expenditure shares as the weights. Japanese prices include import duties and freight (transport) charges. Quantities are the total sales of all models; though for U.S. cars this differs slightly from Dixit's use of production minus exports plus imports from Canada, the difference is far less than 1 percent for the three years of Dixit's data. For Japanese cars, the difference between Dixit's use of imports and our use of sales amounts to nearly 10 percent in 1983, the difference being reflected in changes in inventory stocks. To facilitate comparisons, we use Dixit's numbers for 1979, 1980, and 1983;[12] either way, our results change only slightly.

As always, cost data is more difficult to obtain. As Dixit notes, true marginal costs should take into account the shadow price of investment. Following

11. Simulations using the disaggregated CVs can be found in Krishna, Hogan, and Swagel (1989).

12. Japanese sales were 1,833,744 in 1979, 1,977,018 in 1980, and 1,911,318 in 1983.

Table 1.1 **Data**

		1979	1980	1981	1982	1983	1984	1985
Autos (million)	Q_1	8.341	6.581	6.206	5.757	7.020	7.952	8.205
	Q_2	1.546	1.819	1.892	1.801	2.112	1.906	2.218
Price ($)	v	5,951	6,407	6,740	6,880	7,494	8,950	10,484
	w	4,000	4,130	4,580	4,834	5,239	5,518	6,069
Cost ($)	d	5,400	6,100	6,362	6,636	7,000	7,301	7,615
	d^*	3,400	3,800	3,963	4,121	4,400	4,589	4,786
Firms	n	2.250	2.077	2.100	2.200	2.262	2.300	2.310
	m	4.040	4.034	4.210	4.250	4.350	4.460	4.400
Labor rent		1,000	1,200	1,272	1,327	1,400	1,460	1,523
Total elasticity of demand			$\varepsilon = 1.1$					
Elasticities of substitution			$\sigma = 2.0$					
			$\sigma_v = 3.0$					

Dixit, however, we ignore this complicated intertemporal issue and include only labor and materials costs in our data. The costs in table 1.1 should thus be seen as a lower bound on actual marginal costs. We use Dixit's cost figures for 1979, 1980, and 1983 and adjust these figures for other years, following the method described by Dixit. For domestic autos, production costs are broken into labor and component/materials costs. Labor costs are adjusted in each year by Bureau of Labor Statistics (BLS) figures for automobile industry compensation rate changes and then by an additional 2 percent for productivity changes. Component/materials costs are adjusted by the wholesale price index from the IMF *International Financial Statistics* (*IFS*). For Japanese costs, we use the *IFS* manufacturing wages index to adjust Dixit's figures for materials costs, the *IFS* wage/price index for labor costs, *IFS* statistics for exchange rate changes, and data from the World Bank *Commodity Trade and Price Trends* to adjust for changes in ocean freight costs.

We use market share data in the *ANMDB* to calculate Herfindahl numbers-equivalents on a firm basis, which we denote as n for the United States and m for Japan.[13]

1.3 Implementing the Model

We use the data in table 1.1 to calibrate the model for the years 1979 to 1985. The resulting parameter values for market (consumer) and firm behavior are summarized in tables 1.2 and 1.3, respectively.

13. Note that since we assume product differentiation within each country, the Herfindahl numbers-equivalent—the number of symmetric firms that would reproduce the existing market shares—is not really the proper measure, as the number of firms n and m are not truly exogenous. Our use of the Herfindahl index should thus be taken as an approximation. While it is a simple matter to add two equations to endogenize n and m, the computational burden becomes much greater.

1.3.1 Calibration Results

Table 1.2 summarizes the parameters which describe market (consumer) behavior. For $\sigma_y = 3.0$, the value of σ_x is remarkably constant and lies around 1.3 for all years. That the elasticity of substitution between U.S. goods is always smaller than that for Japanese goods suggests that U.S. autos are less interchangable than Japanese autos. This seems plausible as U.S. cars seem more differentiated from one another than are Japanese cars.

This is reflected in the elasticities of demand. That $\varepsilon^{ii}(x,x)$ and $\varepsilon^{ij}(x,x)$ are respectively smaller than $\varepsilon^{ii}(y,y)$ and $\varepsilon^{ij}(y,y)$ shows that demand for Japanese cars with respect to other Japanese cars is more price elastic than demand for U.S. cars with respect to other U.S. cars. Indeed, the demand for Japanese cars in general reacts more to price changes, by both national and international competitors. That $\varepsilon^{ij}(y,x)$ is an order of magnitude larger than $\varepsilon^{ij}(x,y)$ illustrates this. The two "own" elasticities $\varepsilon^{ii}(x,x)$ and $\varepsilon^{ii}(y,y)$ are orders of magnitude larger than the ε^{ij}'s because they reflect the effect on a firm which raises its own price and thus loses demand to all other firms. The four ε^{ij}'s, on the other hand, are smaller because they measure the gain of only one of the many firms which benefit when another firm changes its price.

Table 1.2 **Market Behavior**

	1979	1980	1981	1982	1983	1984	1985
β[a]	10.574	9.813	10.150	9.838	12.681	15.532	18.838
σ_x	1.255	1.255	1.277	1.304	1.308	1.265	1.267
Elasticities of demand							
$\varepsilon^{ii}(x,x)$	1.231	1.246	1.266	1.285	1.285	1.244	1.247
$\varepsilon^{ij}(x,x)$	0.025	0.009	0.011	0.019	0.023	0.021	0.019
$\varepsilon^{ii}(y,y)$	2.728	2.718	2.726	2.727	2.734	2.750	2.745
$\varepsilon^{ij}(y,y)$	0.272	0.282	0.274	0.273	0.266	0.250	0.255
$\varepsilon^{ij}(x,y)$	0.025	0.034	0.037	0.038	0.036	0.026	0.028
$\varepsilon^{ij}(y,x)$	0.356	0.368	0.355	0.335	0.329	0.341	0.337
Cross-elasticities of demand							
$L(Q_1,v)$	1.200	1.236	1.254	1.262	1.256	1.216	1.222
$L(Q_1,w)$	0.100	0.136	0.154	0.162	0.156	0.116	0.122
$L(Q_2,w)$	1.900	1.864	1.846	1.838	1.844	1.884	1.878
$L(Q_2,v)$	0.800	0.764	0.746	0.738	0.744	0.784	0.778
Calibration using Levinsohn's cross-elasticities							
$\varepsilon^{ii}(x,x)$	1.219	1.226	1.238	1.251	1.251	1.227	1.228
$\varepsilon^{ij}(x,x)$	−0.022	−0.019	−0.009	0.003	0.004	−0.016	−0.014
$\varepsilon^{ii}(y,y)$	2.662	2.662	2.676	2.679	2.686	2.694	2.690
$\varepsilon^{ij}(y,y)$	0.338	0.338	0.324	0.321	0.314	0.306	0.310
$\varepsilon^{ij}(x,y)$	0.014	0.021	0.024	0.026	0.024	0.015	0.016
$\varepsilon^{ij}(y,x)$	0.197	0.228	0.234	0.227	0.218	0.198	0.200
$L(Q_1,w)$	0.055	0.084	0.102	0.110	0.104	0.067	0.072
$L(Q_2,v)$	0.444	0.473	0.491	0.499	0.493	0.456	0.461

[a]β is reported in 10 billions.

As a further check on these demand elasticities, we calculate the resulting aggregate cross-elasticities of demand and compare them to estimates in Levinsohn (1988).[14] The U.S.-U.S. cross-elasticity, which we denote as $L(Q_1,v)$, is the percentage quantity change in U.S. auto sales given an equiproportionate change in the price of all U.S. cars. Similarly, we denote the U.S.-Japan cross-elasticity—the response of U.S. sales to an equiproportionate change in Japanese prices—as $L(Q_1,w)$. The Japan-Japan and Japan-U.S. cross-elasticities are $L(Q_2,w)$ and $L(Q_2,v)$, respectively. As usual, we define these elasticities so that they are typically positive.

For our specification,

$$L(Q_1, v) = -\left[\frac{\partial nx(v^1, \dots, v^n, w^1, \dots, w^m)}{\partial v}\right]\frac{v}{nx} = \frac{1 - r + \varepsilon\phi}{1 + \phi},$$

$$L(Q_1, w) = \left[\frac{\partial nx(v^1, \dots, v^n, w^1, \dots, w^m)}{\partial w}\right]\frac{w}{nx} = \frac{1 - r - \varepsilon}{1 + \phi},$$

$$L(Q_2, w) = -\left[\frac{\partial my(v^1, \dots, v^n, w^1, \dots, w^m)}{\partial w}\right]\frac{w}{my} = \frac{(1 - r)\phi + \varepsilon}{1 + \phi}, \text{ and}$$

$$L(Q_2, v) = \left[\frac{\partial my(v^1, \dots, v^n, w^1, \dots, w^m)}{\partial v}\right]\frac{v}{my} = \frac{(1 - r - \varepsilon)\phi}{1 + \phi}$$

Table 1.2 contains the aggregate cross-elasticities which result from our model, along with the ε^{ij}'s—the individual firm elasticities of demand. Our results of 1.200–1.263 for $L(Q_1,v)$ correspond well with Levinsohn's estimates of 0.967–1.412. For $L(Q_1,w)$, our results of 0.100–0.162 are similarly roughly in line with Levinsohn's estimates of 0.086–0.226. Note that after 1979, U.S. firms become markedly more responsive to changes in Japanese prices; 1979 is the year in which U.S. auto manufacturers first appealed for import protection. However, our results of 1.838–1.900 for $L(Q_2,w)$ differ significantly from Levinsohn's estimates of 1.080–1.636, while our results of 0.738–0.800 for $L(Q_2,v)$ differ from Levinsohn's figures of 0.122–0.231.

An alternative approach to the calibration sheds light on the implications of these differences. Since ϕ can be calculated from market-share data, assuming values for the own-country cross-elasticities $L(Q_1,v)$ and $L(Q_2,w)$ lets us solve for ε and σ. The rest of the calibration then proceeds as before. The bottom of table 1.2 shows the behavioral parameters and jointly optimal policies and welfare which result from setting $L(Q_1,v) = 1.247$ and $L(Q_2,w) = 1.636$, which are the Levinsohn estimates with the smallest standard errors. Except in 1982 and 1983, $\varepsilon^{ij}(x,x)$ is negative, indicating that U.S. cars are complements for one

14. Levinsohn's estimates come from an econometric study using a panel of data for 100 different models over the years 1983–85. He presents four different estimates for each of the cross-elasticities, which he takes as constant over the years examined. See Levinsohn (1988, tables 2.4–2.7).

Table 1.3 **Firm Behavior**

	1979	1980	1981	1982	1983	1984	1985
Conjectural variations							
γ	−9.57	−19.62	−16.56	−26.91	−13.89	−4.18	−2.41
γ^*	−5.27	−15.24	−6.13	−5.16	−4.36	−3.91	−2.39
γ_C	0.0410	0.0510	0.0537	0.0520	0.0496	0.0417	0.0413
γ_C^*	0.2064	0.2287	0.2354	0.2385	0.2311	0.2002	0.2013
U.S. prices							
v	5,951	6,407	6,740	6,880	7,494	8,950	10,484
v_B	23,895	25,257	24,898	25,028	26,626	31,450	32,788
v_C	26,553	28,434	27,928	27,827	29,494	34,851	36,308
Japan prices							
w	4,000	4,130	4,580	4,834	5,239	5,518	6,069
w_B	5,567	6,220	6,471	6,723	7,152	7,416	7,733
w_C	5,857	6,591	6,867	7,139	7,574	7,780	8,117
U.S. costs							
d	5,400	6,100	6,362	6,636	7,000	7,301	7,615
d_B	1,115	1,265	1,417	1,527	1,662	1,753	2,077
d_C	1,032	1,147	1,283	1,390	1,521	1,618	1,915
Japan costs							
d^*	3,400	3,800	3,963	4,121	4,400	4,589	4,786
d_B^*	2,433	2,511	2,800	2,961	3,223	3,411	3,758
d_C^*	2,357	2,419	2,696	2,849	3,106	3,307	3,640

another, rather than substitutes. While the optimal policies and welfare do not change by much, this improbable result makes us wary of Levinsohn's estimate for $L(Q_2,w)$.

Table 1.2 also summarizes the value of β, which gives an indication of the strength of demand. While demand for autos was relatively strong in 1979, it weakened in 1980, a year in which the three major U.S. producers all suffered losses.[15] This is picked up by the fall in β between these years. The rise in β in 1983 coincides with the comeback of U.S. firms, as Ford and General Motors edged back into profitability after the dismal years (for U.S. firms) of 1980–82.

Table 1.3 summarizes the parameters which describe firm behavior. The estimates of γ and γ^*, parametrize the degree of competition among U.S. and Japanese firms, respectively. A zero value for γ indicates Bertrand competition. The estimates derived are uniformly negative, suggesting that firms' behavior is more competitive than that of Bertrand oligopolists. This contrasts with Dixit's result that competition lies somewhere between Cournot and Bertrand. With Dixit's assumption of perfect substitutability between all home goods and between all foreign goods, any markup of price over cost implies conduct less competitive than Bertrand. By introducing product differentiation within

15. Halberstam (1986) provides a fascinating history of the U.S. and Japanese automobile industries.

goods made at home and within those made abroad, we do not implicitly restrict the calibrated conjectures in this way.

From 1979 to 1980, these conjectures become more negative, suggesting a greater degree of competition in 1980 than in 1979. This is not surprising, as demand was relatively slack in 1980. With VERs in place starting in 1981, Japanese firms appear to behave less competitively, while U.S. firms continue to act in a relatively competitive manner. This is consistent with Dixit's result that collusion between U.S. firms does not appear to be greatly strengthened by VERs. By 1984, however, U.S. firms appear to match Japanese firms in acting less competitively, though both continue to behave more competitively than Bertrand duopolists. The need to catch up to Japanese competitors apparently prodded U.S. firms into a period of competitive behavior, after which they reverted to relatively collusive behavior.

In order to better interpret the meaning of the values of the CVs γ and γ^* we also calculate the prices of U.S. and Japanese autos that would exist were behavior Bertrand or Cournot. The Bertrand-equivalent prices are calculated by solving for v and w in (3) and (4), with γ and γ^* fixed at zero, and substituting for $\varepsilon^{ij}(x,x)$ and $\varepsilon^{ii}(y,y)$. These are given by v_B and w_B in table 1.3.

To calculate the Cournot-equivalent prices, we solve (3) and (4) in conjunction with equations (5)–(8) given below, which restrict firms' beliefs (γ^{ij}'s) to competition in quantities. The Cournot-equivalent prices v_C and w_C and aggregate CVs γ_C and γ_C^* are presented in table 1.3.

For a U.S. firm to assume that other U.S. firms do not vary their output, it must assume that prices change so that

$$(5) \qquad \varepsilon^{ij}(x, x)(1 + (n - 2)\gamma^{11}) - \varepsilon^{ii}(x, x)\gamma^{11} + m\varepsilon^{ij}(x, y)\gamma^{12}\frac{v}{w} = 0.$$

For a U.S. firm to assume that Japanese firms do not change their output, it must assume that

$$(6) \quad \varepsilon^{ij}(y, x)(1 + (n - 1)\gamma^{11}) + \frac{v}{w}\gamma^{12}\,[\varepsilon^{ij}(y, y)(m - 1) - \varepsilon^{ij}(y,y)] = 0.$$

Similarly, for a Japanese firm to assume that other Japanese firms do not change their output as it varies its own price, it must assume that

$$(7) \qquad \varepsilon^{ij}(y, y)(1 + (m - 2)\gamma^{22}) - \varepsilon^{ii}(y, y)\gamma^{22} + n\varepsilon^{ij}(y, x)\gamma^{21}\frac{w}{v} = 0.$$

For a Japanese firm to assume that U.S. firms do not vary their output, it must assume that

$$(8) \quad \varepsilon^{ij}(x, y)(1 + (m - 1)\gamma^{22}) + \frac{w}{v}\gamma^{21}\,[\varepsilon^{ij}(x, x)(n - 1) - \varepsilon^{ii}(x, x)] = 0.$$

For firms to behave in a Cournot fashion and for this behavior to replicate the market outcome, v, w, γ^{11}, γ^{12}, γ^{21}, γ^{22} must be such that equations (3)–(8) are satisfied simultaneously.

We similarly calculate the Bertrand- and Cournot-equivalent costs for both U.S. and Japanese firms. These appear at the bottom of table 1.3 as d_B, d_C, d_B^*, and d_C^*. We discuss these results in section 1.3.4.

Because we find behavior to be less collusive than that of Bertrand oligopolists, the Bertrand-equivalent price for both domestic and foreign cars is higher than the actual price, while the Cournot-equivalent price is higher still. Note, however, that while the Bertrand- and Cournot-equivalent prices for U.S. firms are much higher than actual prices, the equivalent prices for Japanese firms are quite close to actual prices v and w, which are shown in the middle of table 1.3. This indicates that the behavior of Japanese firms is fairly close to that of Bertrand (and Cournot) oligopolists, while U.S. firms exhibit far more competitive behavior.

1.3.2 Welfare

We now calculate the optimal policies which arise from maximization of the welfare function. The first-order conditions (3) and (4) together define how domestic price, v, and foreign price, w, adjust for a given subsidy, s, and tariff, t. In turn, v and w determine U.S. and Japanese outputs. Since v and w are nonlinear simultaneous functions of s and t, (3) and (4) must be solved numerically for every s and t. The resulting v and w are then used to calculate a value for welfare. The jointly optimal subsidy and tariff are thus the s and t which maximize the welfare function. For the optimal tariff by itself, s is set to 0, while for the optimal subsidy by itself, we set t to the most-favored-nation (MFN) level of \$100.

As explained in section 1.2.1, we assume a numeraire good, n_0, and a utility-maximizing aggregate consumer. We assume that all revenues are given back to this aggregate consumer, so that welfare is given by

$$W(s, t) = U(S(s, t)) - ndx(s, t) - (w - t)my(s, t)$$

when there are no rents to labor. Following Dixit, we assume labor rents to be a constant 20 percent of domestic costs in each year. For 1979, Dixit notes that this corresponds to about half of the wage bill. Rents are then subtracted from domestic cost d in the second term of the welfare function.

1.3.3 Optimal Policies

Tables 1.4 and 1.5 summarize the policy and welfare results for 1979–85. In all following tables, welfare is shown in billions of dollars. The first thing to notice is that in all years the jointly optimal policy is to subsidize both domestic production and imports. This contrasts with Dixit's results, which call for a subsidy on domestic production but a tariff on imports.

In order to understand why the sign of the import policy differs between our model and Dixit's, consider the derivative of welfare with no labor rents at t and s equal to zero:

Table 1.4 Policy Results—No Labor Rent

	1979	1980	1981	1982	1983	1984	1985
Jointly optimal policies							
Subsidy	528	312	405	298	528	1,389	2,139
Tariff	−245	−122	−268	−318	−377	−404	−558
v	5,369	6,079	6,311	6,571	6,929	7,249	7,545
w	3,606	3,895	4,165	4,355	4,684	4,925	5,251
Q_1	9,339,751	6,966,457	6,641,703	5,996,750	7,611,905	10,135,979	12,028,153
Q_2	1,734,165	1,949,192	2,146,008	2,108,682	2,449,221	2,001,047	2,249,905
Welfare[a]	563.279	499.049	507.623	484.829	640.654	831.912	1,023.592
Optimal tariff only							
Subsidy	0	0	0	0	0	0	0
Tariff	−102	−41	−166	−245	−244	−24	27
v	5,951	6,407	6,740	6,880	7,494	8,950	10,480
w	3,769	3,891	4,280	4,439	4,839	5,372	5,978
Q_1	8,290,636	6,547,626	6,140,050	5,674,886	6,930,603	7,927,060	8,190,322
Q_2	1,730,508	1,948,058	2,142,799	2,105,861	2,444,186	2,004,723	2,281,226
Welfare[a]	562.982	498.981	507.516	484.780	640.463	830.154	1,018.548
Optimal subsidy only							
Subsidy	491	277	342	219	447	1,339	2,085
Tariff	100	100	100	100	100	100	100
v	5,410	6,116	6,378	6,653	7,016	7,311	7,624
w	4,000	4,130	4,580	4,834	5,239	5,517	6,067
Q_1	9,347,531	6,969,203	6,650,342	6,005,257	7,624,480	10,148,407	12,049,094
Q_2	1,432,016	1,755,363	1,815,162	1,757,361	2,010,503	1,623,802	1,723,339
Welfare[a]	563.225	499.027	507.561	484.754	640.546	831.814	1,023.412
Status quo							
Subsidy	0	0	0	0	0	0	0
Tariff	100	100	100	100	100	100	100
v	5,951	6,407	6,740	6,880	7,494	8,950	10,484
w	4,000	4,130	4,580	4,834	5,239	5,518	6,069
Q_1	8,341,000	6,581,000	6,206,296	5,756,660	7,020,000	7,951,517	8,204,721
Q_2	1,546,000	1,819,000	1,891,769	1,801,481	2,112,000	1,906,208	2,217,850
Welfare[a]	562.963	498.972	507.483	484.727	640.406	830.148	1,018.545

[a]Welfare reported in billion dollars.

Table 1.5 Policy Results—With Labor Rent

	1979	1980	1981	1982	1983	1984	1985
Jointly optimal policies							
Subsidy	1,426	1,448	1,590	1,557	1,814	2,567	3,231
Tariff	−242	−119	−263	−311	−370	−398	−550
v	4,379	4,886	5,056	5,266	5,552	5,806	6,046
w	3,609	3,898	4,170	4,363	4,691	4,931	5,260
Q_1	11,904,968	9,104,444	8,753,861	7,920,674	10,034,817	13,219,449	15,673,308
Q_2	1,468,333	1,643,050	1,810,673	1,782,521	2,066,796	1,670,132	1,875,887
Welfare[a]	573.809	508.592	517.308	493.962	652.872	848.785	1,044.467
Optimal tariff only							
Subsidy	0	0	0	0	0	0	0
Tariff	180	290	178	111	135	369	409
v	5,951	6,407	6,740	6,880	7,494	8,951	10,490
w	4,091	4,331	4,668	4,847	5,280	5,834	6,452
Q_1	8,359,537	6,622,834	6,224,367	5,759,085	7,028,460	8,000,855	8,261,727
Q_2	1,481,012	1,664,472	1,826,520	1,792,889	2,082,063	1,716,007	1,976,865
Welfare[a]	571.307	506.883	515.379	492.366	650.234	841.781	1,031.076
Optimal subsidy only							
Subsidy	1,401	1,425	1,547	1,504	1,760	2,534	3,195
Tariff	100	100	100	100	100	100	100
v	4,407	4,910	5,101	5,321	5,610	5,848	6,098
w	4,000	4,130	4,579	4,833	5,238	5,517	6,066
Q_1	11,913,770	9,108,249	8,761,021	7,929,342	10,048,377	13,325,997	15,692,584
Q_2	1,211,527	1,478,861	1,530,159	1,484,537	1,694,871	1,647,189	1,436,555
Welfare[a]	573.764	508.574	517.256	493.899	652.783	848.704	1,044.318
Status quo							
Subsidy	0	0	0	0	0	0	0
Tariff	100	100	100	100	100	100	100
v	5,951	6,407	6,740	6,880	7,494	8,950	10,484
w	4,000	4,130	4,580	4,834	5,239	5,518	6,069
Q_1	8,341,000	6,581,000	6,206,296	5,756,660	7,020,000	7,951,517	8,204,721
Q_2	1,546,000	1,819,000	1,891,769	1,801,481	2,112,000	1,906,208	2,217,850
Welfare[a]	571.304	506.869	515.377	492.366	650.234	841.757	1,031.041

[a]Welfare reported in billion dollars.

$$\left.\frac{\partial W}{\partial t}\right|_{s=t=0} = n(U_x - d)\frac{\partial x}{\partial t} - my\left(\frac{\partial w}{\partial t} - 1\right).$$

Note that at this point there are only two terms in this expression. The first term is positive in both models, since marginal utility equals price, which exceeds costs, and since a tariff raises domestic production in both models, which implies that $\partial x/\partial t$ is positive. In Dixit's model, however, $\partial w/\partial t$ is less than unity, while it exceeds unity in ours. Hence the second term, $-my(\partial w/\partial t - 1)$, is positive in Dixit's model but negative in ours. As the welfare function is well behaved this leads to the optimal tariff being positive in his model. In ours, the second term outweighs the first at $s = t = 0$, so that a subsidy on imports improves welfare.

Intuitively, trade policy seems to play two roles here. The first is a profit-shifting role in correcting any "strategic distortion" à la Eaton and Grossman (1986). Second, since trade policy affects domestic consumption, it also affects the size of consumer surplus. Our model implies that the behavior of firms is fairly competitive. This by itself should work toward reversing the sign of the optimal trade policy, since the direction of the profit-shifting policy depends on the degree of competition. In addition, our CES demand parametrization implies that consumer surplus is quite important, since demand resembles a hyperbola. This in turn strengthens the reasons to subsidize both domestic and foreign output. Hence, we believe that the calibration results for implied conduct together with the effect of the demand parametrization itself on the importance of consumer surplus in welfare is responsible for the differences between our results and Dixit's.

Next compare the jointly optimal subsidy when there are no labor rents to the case with labor rents. The optimal policy with rents involves a higher subsidy on production than without. This is to be expected, as the presence of rents makes domestic production more desirable. Also notice that the optimal tariff changes only very slightly. This suggests a targeting interpretation. The presence of labor rents distorts production, as firms produce too little, both because they have monopoly power and because they do not take labor rents into account in their production decisions. Hence the optimal policy to correct this distortion is a domestic production subsidy, which targets the domestic distortion directly, rather than a trade policy, which targets the distortion only indirectly.

When the production subsidy is unavailable, the optimal tariff in the presence of labor rents is positive for all years, as opposed to the import subsidy typically optimal in the absence of labor rents. Again this is expected, as the tariff must partly do the job of the unavailable production subsidy, and the higher tariff encourages domestic production. The presence of labor rents thus dramatically changes the nature of the optimal policies.

Next compare the jointly optimal tariffs with and without labor rents to the optimal tariffs when a production subsidy is unavailable. The tariff is always larger (less negative) in the latter case. Again, this has a targeting interpretation. When a subsidy is unavailable, the tariff targets the monopoly distortion which is really best targeted by the subsidy. Similarly, comparing the jointly optimal subsidy and the optimal subsidy when the tariff is set to the MFN level shows that the subsidy is slightly lower when applied by itself. When the tariff is not available, reducing the subsidy on production acts to encourage imports.

In the above comparisons, we see at work the general principle of targeting instruments to the relevant distortion. We also see that in the absence of an instrument, the optimal level of the remaining instrument is set to help reduce other distortions. Dixit offers similar interpretations.

A natural question to ask next is how valuable such policy is in raising welfare. The welfare levels with both t and s set optimally, with only t set optimally, and with only s set optimally are also given in tables 1.4 and 1.5. Here our results are in line with Dixit's—the gains to be had are very limited, with most of the benefit coming from the production subsidy rather than from a tariff on imports.

In the absence of labor rents, gains range from a high of about $5 billion in 1985 to less than $80 million in 1980.[16] Welfare gains are larger when labor rents constitute a share of the domestic wage bill, since the increased domestic production that results from optimal policies adds to consumer surplus and to workers' rents, both of which the price-setting firm ignores. With our assumption of labor costs as 20 percent of unit cost (half of the wage bill), welfare gains from jointly optimal policies range from $13 billion in 1985 to $1.7 billion in 1980. The presence of labor rents thus provides greater scope for strategic trade policy (see, e.g., Katz and Summers 1989). And yet these gains remain fairly minor relative to the size of the markets involved.

Moreover, it may be worse to implement the wrong policy than to do nothing. For example, if the optimal policies that result from Dixit's model are used instead of the ones identified as optimal by our model, welfare is slightly lower in some years. Table 1.6 compares the status quo (MFN tariff, no subsidy) welfare level (W^{MFN}) with the welfare which results from application of the optimal policies suggested by our CES model (W^{CES}) and the welfare which results from Dixit's optimal policies (W^{D}). Implementing Dixit's policies reduces welfare in the absence of labor rents in 1981, 1982, and 1983 but raises welfare over inaction in the remaining years. With labor rents, Dixit's policies reduce welfare in 1985 but increase it in other years. Of course, the lack of responsiveness in welfare also implies that the loss from following the wrong policies is likely to be small—a conclusion borne out for 1981–83. In 1985,

16. Potential gains in 1985 are particularly large because firm behavior in that year is not very competitive. This increases the welfare gains available from increasing output with a production subsidy.

Table 1.6 Comparison of Models

	1979	1980	1981	1982	1983	1984	1985
			No Labor Rent				
CES model							
Subsidy	528	312	405	298	528	1,389	2,141
Tariff	−245	−122	−268	−318	−377	−404	−558
Dixit's linear model							
Subsidy	611	325	408	258	538	2,029	3,847
Tariff	408	211	440	521	604	621	809
Welfare[a]							
W^{CES}	563.28	499.05	507.62	484.83	640.65	831.91	1,023.59
W^{D}	563.09	499.00	507.42	484.57	640.26	830.81	1,023.11
W^{MFN}	562.96	498.97	507.48	484.73	640.41	830.15	1,018.55
			With Labor Rent				
CES model							
Subsidy	1,426	1,448	1,590	1,557	1,814	2,567	3,231
Tariff	−242	−119	−263	−311	−370	−398	−550
Dixit's linear model							
Subsidy	1,712	1,590	1,768	1,643	2,044	3,812	5,871
Tariff	357	181	389	461	529	553	731
Welfare[a]							
W^{CES}	573.81	508.59	517.31	493.96	652.87	848.79	1,044.47
W^{D}	573.46	508.52	517.09	493.74	652.46	843.37	971.07
W^{MFN}	571.30	506.87	515.38	492.37	650.23	841.67	1,031.04

[a]Welfare reported in billion dollars.

however, application of the optimal tariff and subsidy which result from Dixit's model entails a decline in welfare of nearly $60 billion in the presence of labor rents. Misguided policy decisions can indeed prove costly in certain cases.

As shown by Krishna (1989), however, quantitative restraints such as VERs differ fundamentally from tariffs in that they facilitate collusive behavior by the competing firms. The existence of VERs starting in 1981 thus affects firm behavior, as reflected in the CVs γ and γ^*. The rise in γ^* corresponding to the imposition of VERs in 1981, and in γ after 1983, supports this theory. Our simulation results for these years, however, take γ and γ^* as fixed behavioral parameters. These CVs are surely inappropriate for calculating the optimal tariff and subsidies, since these policies do not have the collusion-increasing effects of VERs.

As an attempt to correct for this problem of static CVs, we double the γ and γ^* that result from the calibration for 1983 before finding the optimal subsidy and tariff. This experiment, which makes γ and γ^* more negative, thus imposes the more competitive conjectures Krishna (1989) tells us should exist in the absence of a VER. Of course, we have no way of knowing whether our modification is sufficient (or too much); we mean this only as a first step.

Table 1.7 compares the prices, policies, and welfare which result from the

Table 1.7 Effect of Voluntary Export Restraints

	MFN Tariff		Tariff Rate Quota	Jointly Optimal	
	Actual CVs	Modified CVs		Actual CVs	Modified CVs
			No Labor Rent		
γ	−13.885	−27.770	−27.770	−13.885	−27.770
γ^*	−4.355	−8.710	−8.710	−4.355	−8.710
v	7,494	7,249	7,250	6,929	6,954
w	5,239	4,931	5,170	4,684	4,570
Subsidy	0	0	0	528	285
Tariff	100	100	318	−377	−229
Q_1	7,020,000	7,249,339	7,303,303	7,611,905	7,546,347
Q_2	2,112,000	2,304,043	2,111,708	2,449,221	2,568,974
Welfare[a]	640.406	641.189	641.117	640.6549	641.277
			Labor Rent = $1400		
γ	−13.885	−27.770	−27.770	−13.885	−27.770
γ^*	−4.355	−8.710	−8.710	−4.355	−8.710
v	7,494	7,249	7,250	5,552	5,570
w	5,239	4,931	5,170	4,691	4,576
Subsidy	0	0	0	1,814	1,622
Tariff	100	100	318	−370	−224
Q_1	7,020,000	7,249,339	7,303,303	10,034,817	9,962,263
Q_2	2,112,000	2,304,043	2,111,708	2,066,796	2,170,450
Welfare[a]	650.2346	651.338	651.342	652.872	653.398

[a]Welfare reported in billion dollars.

modified CVs for 1983 with those from the original CVs, both at the actual MFN tariff and at the jointly optimal policy. The first two columns compare the actual MFN tariff results with the results of the modified CFs. Without the VER, both domestic and foreign prices would be lower, and consumption of both countries' cars higher. Welfare rises by about $700 million or $1.1 billion, depending on whether labor rents exist. This experiment thus highlights the point that a tariff is (from the standpoint of efficiency) a far better instrument with which to protect domestic industries than a quantitative restraint. The third column shows the quota-equivalent tariff rate, that is, the tariff (to the nearest dollar) required to duplicate the original level of Japanese imports assuming the less collusive conjectures. Notice that for the same volume of imports, U.S. production is substantially larger with a tariff than with a VER.

The next two columns compare the jointly optimal subsidy and tariff outcomes with the results of modifying the CVs. The more competitive behavior on the part of firms lessens the size of the oligopoly distortions, so that both domestic and import subsidies decline. U.S. producers thus lose some market share to Japanese firms, but the increased consumer surplus results in a slight gain in welfare.

1.3.4 Sensitivity Analysis

We next consider how sensitive our results are to the calibration parameters we obtain from outside sources. In the interest of brevity, we present sensitivity results only for 1979; similar results obtain for the other years.

Table 1.8 shows the effect of changing U.S. and Japanese costs over the same range considered by Dixit. This affects firms' behavioral parameters γ and γ^* and the resulting optimal policies and welfare. Notice that the estimate of γ (γ^*) becomes more negative as costs in the United States (Japan) rise, since a smaller markup of price over marginal cost indicates more competitive behavior. Similarly, γ and γ^* rise to reflect more collusive behavior as costs decline, though both remain negative for the range of plausible costs.

As Japanese costs rise, the optimal subsidy falls slightly, while the optimal tariff rises markedly, though it remains negative. Similarly, as U.S. costs rise, the optimal subsidy falls, while the optimal tariff remains relatively constant. This further reinforces the targeting interpretation given before. As Japanese firms' costs rise, their implied behavior becomes more competitive, thereby reducing the desirability of subsidizing imports. Similarly, as U.S. costs rise, implied U.S. firm behavior becomes more competitive, reducing the size of the domestic distortion targeted by the subsidy.

Welfare at the optimum falls when U.S. costs rise, since the resource costs of production enter the welfare function directly. Welfare is relatively unaffected by Japanese costs, since these enter only via their impact on prices. Again, however, welfare falls, as higher costs mean higher prices.

Table 1.8 **Cost Sensitivity: 1979 (labor rent = 0)**

		Japan Cost		
U.S. Cost		3,000	3,400	3,600
5,000	γ	−5.027	−5.027	−5.027
	γ^*	−1.717	−5.272	−10.606
	Subsidy	842	822	812
	Tariff	−408	−244	−151
	Welfare[a]	567.280	567.189	567.162
5,400	γ	−9.570	−9.570	−9.570
	γ^*	−1.717	−5.272	−10.606
	Subsidy	553	528	516
	Tariff	−410	−245	−152
	Welfare[a]	563.376	563.279	563.250
5,600	γ	−15.724	−15.724	−15.724
	γ^*	−1.717	−5.272	−10.606
	Subsidy	389	361	348
	Tariff	−411	−246	−152
	Welfare[a]	561.552	561.451	561.422

[a]Welfare reported in billion dollars.

Table 1.9 shows the sensitivity of our results to the assumed values for the elasticity of demand for auto services, ε, and the elasticity of substitution between U.S. and Japanese autos, σ. While the choice of ε significantly alters the resulting optimal welfare level, the behavioral parameters and the optimal subsidy and tariff levels change only slightly for reasonable values of σ and ε. Furthermore, as ε rises, $\varepsilon^{ij}(x,x)$ and $\varepsilon^{ij}(y,y)$ become negative, which implies that autos are complements in demand. Our parametrization thus puts an upper bound of about 1.3 on the total elasticity of demand. As σ rises, U.S. and Japanese cars become more similar to consumers, so that firms' implied behavior becomes more collusive. The optimal subsidy rises along with the tariff, which becomes less negative.

Table 1.10 shows the sensitivity analysis of the elasticity of substitution among Japanese autos, σ_y. As σ_y increases, σ_x rises only slightly, and σ_y always remains larger. American cars are thus quite differentiated from one another,

Table 1.9 Sensitivity to Elasticity of Demand and Elasticity of Substitution: 1979 (labor rent = 0)

Elasticity of Demand (ε)		Elasticity of Substitution (σ) 1.5	2.0	3.0
1.05	β[a]	42.010	46.650	49.159
	γ	−9.670	−9.590	−9.471
	γ^*	−5.384	−5.274	−5.053
	Subsidy	519	531	541
	Tariff	−308	−247	−182
	Welfare[b]	1,121.482	1,121,480	1,121.484
	$\varepsilon^{ij}(x,x)$	0.024	0.044	0.050
	$\varepsilon^{ij}(y,y)$	0.384	0.274	0.053
1.1	β[a]	8.657	10.574	11.686
	γ	−9.651	−9.570	−9.452
	γ^*	−5.382	−5.272	−5.052
	Subsidy	517	528	538
	Tariff	−307	−245	−180
	Welfare[b]	563.281	563.279	563.282
	$\varepsilon^{ij}(x,x)$	0.004	0.025	0.031
	$\varepsilon^{ij}(y,y)$	0.382	0.272	0.052
1.3	β[a]	0.167	0.278	0.359
	γ	−9.572	−9.491	−9.372
	γ^*	−5.377	−5.267	−5.047
	Subsidy	507	518	529
	Tariff	−300	−239	−174
	Welfare[b]	191.184	191.182	191.186
	$\varepsilon^{ij}(x,x)$	−0.075	−0.054	−0.048
	$\varepsilon^{ij}(y,y)$	0.377	0.267	0.047

[a] β is reported in 10 billions.

[b] Welfare reported in billion dollars.

Table 1.10 **Sensitivity to Elasticity of Substitution among Japanese Automobiles (σ_y): 1979**

	σ_y				
	1.5	2.1	3.0	5.0	50.0
σ_x	1.154	1.216	1.255	1.287	1.323
β[a]	8.741	10.039	10.574	10.915	11.238
γ	−9.626	−9.591	−9.570	−9.552	−9.532
γ^*	−6.401	5.949	−5.272	−3.767	30.094
$\varepsilon^{ii}(x,x)$	1.174	1.209	1.231	1.248	1.268
$\varepsilon^{ij}(x,x)$	−0.020	0.007	0.025	0.039	0.055
$\varepsilon^{ii}(y,y)$	1.599	2.051	2.728	4.233	38.094
$\varepsilon^{ij}(y,y)$	−0.099	0.049	0.272	0.767	11.906
$\varepsilon^{ij}(x,y)$	0.025	0.025	0.025	0.025	0.025
$\varepsilon^{ij}(y,x)$	0.356	0.356	0.356	0.356	0.356

[a]β is reported in 10 billions.

as opposed to Japanese cars, which are far more substitutable in demand. As σ_y becomes large, Japanese cars become closer substitutes, and γ^* becomes very large, implying substantial collusion between Japanese firms. Without differentiation between Japanese cars, any markup of price above cost is evidence of monopoly power. A small σ_y, on the other hand, results in implausible negative values for $\varepsilon^{ij}(x,x)$ and $\varepsilon^{ij}(y,y)$. We thus find a lower bound on σ_y of about 2.0. Again, however, the choice of σ_y does not at all affect prices, which satisfy (3) and (4), or the resulting optimal policies and welfare. An econometrically derived estimate for σ_y would thus allow a more definitive determination of Japanese firms' behavior but would not otherwise affect our results.

These sensitivity analyses imply that the calibration results and the optimal policies are quite insensitive to changes in the parameter values, with the exception of costs. Marginal costs, however, are the least reliable of our data. To ensure that our crucial result of firm behavior more competitive than Bertrand is not merely an artifact of poor data, we calculate the costs which would be necessary for firms to act as if they were Bertrand and Cournot duopolists. These were presented at the bottom of table 1.3.

For U.S. firms, notice that even the higher Bertrand-equivalent costs are far smaller than our data for actual costs. Costs for Japanese firms, on the other hand, are much closer to the Bertrand costs. As with prices, the Bertrand and Cournot costs are fairly close together. While this further illustrates the more collusive behavior of Japanese firms, both U.S. and Japanese firms still appear to behave fairly competitively.

In general, the sensitivity analyses highlight our point that what is most important is not the parameter values, but rather the specification of the model itself.

1.4 Conclusion

Our results indicate that simple calibration models of trade in oligopolistic industries are quite sensitive to the model structure imposed. Though we have taken one step in elaborating Dixit's model, further extensions seem worthwhile.

As noted previously, further disaggregation such as between large cars and small cars would more accurately reflect industry conditions. Whether this would give strikingly different results, however, is uncertain. What is clear is that the resulting model would be extremely complex; our model is already highly nonlinear. Further differentiation would require a substantial amount of additional data, perhaps broken down even by each particular model. Much of this, such as market-share data, is publicly available; other data, particularly costs and elasticities of substitution, would no doubt prove more elusive. Feenstra and Levinsohn (1989) provide an excellent beginning.

Less difficult to implement would be the inclusion of quality effects, an extension on which we are currently at work. Indeed, many studies examine the effects of trade policy on quality upgrading; Feenstra (1988) focuses on the Japanese auto industry. In unpublished work, we show that Dixit's calibration procedure cancels out quality effects, so that quality upgrading plays no role in the determination of optimal policies in his model.[17] This clearly unsatisfactory result stems primarily from Dixit's linear demand structure and is, we hope, not a general feature of calibration models.

One result common to both our model and Dixit's is that the presence of labor rents substantially enlarges the potential benefits of optimal trade policies. This is particularly important since wages in import-competing industries such as steel and autos probably include a large rent component. Following Dixit, we include only the most rudimentary attempt at capturing the effects of these rents. Endogenizing the wage process through inclusion of a formal model of union-firm bargaining (cooperative or not) would no doubt provide great insight. Eaton (1988) provides several suggestions for fruitful research, and work on this is under way.

Our results similarly accord with Dixit's in that we find a surprising amount of "targeting" of instruments to particular distortions. Only limited theoretical work exists on targeting rules for oligopolistic industries analogous to targeting rules for distortions in competitive industries. Krishna and Thursby (1991) provide a beginning, but there remains more work to be done.

We make only a limited attempt to take into account the effects of preexisting quantitative restraints on firms' behavioral conjectures. A more satisfactory way to measure firm interactions is clearly necessary. Recent work on dynamic differential games, such as Driskill and McCafferty (1989), may prove useful here.

17. The proof, which will appear in future work, is available from the authors.

For the present, however, our results suggest that the policy recommendations of simple calibrated trade exercises should be interpreted with extreme caution. Moreover, as the gains from activist policy appear quite small, the case for activist policy is far from clear. However, such exercises provide valuable insights into the behavior of firms over time and the effects of policies on this behavior. They also provide good estimates of demand elasticities. But our understanding of calibrated trade models is far from perfect, and more work is clearly necessary. Until our ability to apply theory to actual industry conditions improves, it remains vital not to oversell such models to policymakers.

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Comment Garth Saloner

Krishna, Hogan, and Swagel's (KHS) purpose is to demonstrate the sensitivity of calibration models of trade to the assumptions that are made about the nature of imperfect competition. They succeed in this goal and reach the appropriate conclusion that "until our ability to apply theory to actual industry conditions improves, it remains vital not to oversell such models to policymakers."

In order to interpret the results in this class of models, it is useful to lay out the essence of the basic approach. The basic structure of the conjectural variations models and the calibration procedure is transparent in the case of homogeneous-goods Cournot duopoly. In that case a typical firm, say firm 1, maximizes its profits given by

$$\pi_1 = P(q_1 + q_2)q_1 - C_1(q_1),$$

where q_i is the output of firm i, $P(\cdot)$ is the industry inverse demand curve, and $C_i(\cdot)$ is firm i's cost function. Maximizing π_1 with respect to q_1 yields:

$$(1) \qquad \frac{\partial \pi_1}{\pi q_1} = P + q_1\frac{\partial P}{\partial q_1} + q_1\frac{\partial P}{\partial q_2}\left(\frac{dq_2}{dq_1}\right) - C_1' = 0.$$

Calling the part of Equation (1) in braces γ (i.e., $dq_2/dq_1 \equiv \gamma$) and rearranging yields:

$$(2) \qquad \frac{P - C'}{P} = \frac{s_1(1 + \gamma)}{\varepsilon},$$

where $(P - C')/P$ is the price-cost margin (PCM), $\varepsilon \equiv -(\partial Q/\partial P)P/Q$ is the industry elasticity of demand, and s_1 is firm 1's market share.

Garth Saloner is professor of economics and management at the Massachusetts Institute of Technology and visiting associate professor of business administration at Harvard University.

The calibration models begin with equations like (2) and, by making assumptions about ε, s_i, and the PCM, calculate γ. The now discredited conjectural variations models (see Tirole [1988] for a discussion) interpret the term in parentheses in equation (1), and hence γ, as a behavioral change in firm 2's action in response to a change in firm 1's action. In a static game the notion of a behavioral response by one firm to another is meaningless and so a *fortiori* is the term dq_2/dq_1 in equation (1).

Taking equation (2) as the starting point, however, γ does have a meaningful interpretation. If the Cournot duopoly model applies, then the PCM is equal to the inverse of the elasticity, i.e., γ is equal to 0 in equation (2). (To see this, simply note that firm 1's first-order condition under Cournot is that given by equation (1) with the third, "nonsense", term omitted). If γ exceeds 0, then the appropriate interpretation is simply that the PCM is higher than would be expected from Cournot duopolists facing an elasticity of ε. Thus γ is a meaningful measure of the degree to which the firms are able to elevate the PCM above "the competitive level" defined in terms of the Cournot equilibrium.

But what is the appropriate inference to make if one finds, as indeed Dixit does, that γ is negative? Then the PCM is lower, and hence competition is fiercer, than in the Cournot model. Since models in which price is the strategic variable can yield much lower PCMs, a natural alternative is to consider a differentiated products model of that kind.

This is the approach that KHS adopt. In their formulation, the crucial equation which is the equivalent of equation (2) above is their equation (3) which can be abbreviated as

$$\text{(3)} \qquad \frac{P - C'}{P} = \frac{1}{\varepsilon^{ii} - \gamma},$$

where ε^{ii} represents firm i's own price elasticity.

The interpretation here is similar to that above. If the firms are competing as static price competition suggests they should, the PCM is again equal to the inverse of the elasticity so that $\gamma = 0$. If the firms are competing less aggressively than that, the PCM should exceed the inverse of the elasticity so that, in order for equation (3) to hold, γ must be positive.

An advantage of this formulation is that it accommodates very competitive outcomes, rather than bounding them from below by the Cournot outcome. If there is a great deal of competition the own-price elasticity will be high and the PCM's will be very low. For example, if the firms face constant marginal costs and compete in prices, the Bertrand result with price equal to marginal cost (and infinitely large own-price elasticity) obtains. Thus in this formulation it should be extremely surprising to encounter negative values of γ.

As KHS's table 1.3 shows, however, not only does γ turn out to be uniformly negative in their calibrations, but γ is less than -9 in five of the seven years, and in 1982 it is -26.91. Referring to equation (3), there are three possible explanations for such a finding: (a) the calibration is plausible and behavior "is more competitive than Bertrand," (b) ε has been mismeasured and is actually greater than the calibration suggests, or (c) the PCM has been mismeasured and is actually lower than the calibration suggests.

Taking (a) first, Might competition actually be more competitive than Bertrand? The "fundamental theorem of industrial organization" asserts that with a sufficiently rich assumption space, modern I.O. can explain any observation! A number of "solutions" readily suggest themselves: (i) the firms are involved in an implicitly collusive supergame and what is being measured is a punishment phase during which firms are using severe punishments of the kind advocated by Abreu (1986), (ii) as in Froot and Klemperer (1989) firms are "buying market share" which will earn them high profits in the future, (iii) the incumbent firms are deterring potential entrants by signaling low costs as in the Milgrom-Roberts (1982) limit-pricing model, (iv) some of the incumbents are attempting to drive out others through predatory pricing, or (v) firms are selling automobiles as a way of later selling automobile parts, and hence the "price" variable understates the value of a sale.

None of these explanations is particularly plausible. First, several of them are really explanations for short-term pricing behavior, whereas the authors find that γ is negative for seven years in a row. Second, KHS calculate the automobile price that would be predicted by their model if the firms were simply behaving as static price competition suggests they should and were not taking into account the kinds of considerations listed in the previous paragraph. The predicted price for a U.S. automobile is of the order of \$25,000! If that is correct, the automobile manufacturers are paying a great deal in short-term forgone profits to deter entry, build market share, drive out or punish rivals, or sell auto parts!

This suggests that either ε or the PCM or both are mismeasured. The estimate of ε is around 1.25. Studies which examine the own-price elasticities of particular automobile models tend to find elasticities in the range 5–16 (see Adams and Brock 1982). One troubling feature of the way in which ε^{ii} is measured by KHS is the way in which it is derived from the degree of substitutability between goods of two producers of Japanese cars, σ_y, and the corresponding measure for substitutability between goods produced by U.S. producers, σ_x.

The procedure they use is as follows: Their equations (1) and (2) specify the demands for U.S. and Japanese cars, Q_1 and Q_2, respectively, as functions of inter alia σ_x and σ_y, i.e., $Q_1 = f(\sigma_x,\sigma_y, \ldots)$ and $Q_2 = f(\sigma_x,\sigma_y, \ldots)$. In the calibration σ_y is set by the authors and σ_x is then *derived* using the assumed functional form of the demand functions and the observed sales of U.S. and Japanese cars. This procedure places a large burden on the functional-form assumptions on demand to yield information on the value of underlying taste parameters. That is, the degree of substitutability between cars produced by two U.S. firms, a "marginal" concept, is inferred from the ratio of actual sales of U.S. and Japanese cars each year, an "average" measure.

Nonetheless, it is unlikely that mismeasurement in ε alone is enough to explain the observed γ's. In 1982 the PCM is about 1/33, so that for γ to be nonnegative, ε^{ii} would have to be 33, which seems implausibly large.

Thus the measured PCMs must probably share in the blame: they are too low to be consistent with "reasonable" elasticity estimates. One possible reason why the measured PCMs may be too low is the difficulty of measuring marginal costs correctly. For example, the PCMs compiled by the Census Bureau use a measure of "payroll and materials." Yet many of the payroll costs represent the fixed costs of the minimum number of workers required to operate the assembly line and the hoards of paper shufflers who contribute to a fixed overhead rather than to marginal costs.

In the end, however, for the conclusion that the authors reach, it doesn't matter whether it is ε or the PCM that is mismeasured. If, as seems likely, there is significant mismeasurement in one or the other or both, then as KHS conclude, it is premature to use models of this kind for policy analysis.

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