NBER WORKING PAPER SERIES

THE EXTENT AND SOURCES OF COST AND EFFICIENCY DIFFERENCES BETWEEN U.S. AND JAPANESE AUTOMOBILE PRODUCERS

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Working Paper No. 1849

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
March 1986

Financial support from the Ontario Council and National Science Foundation (Grant No. SES-8420937) is gratefully acknowledged. We are indebted to Jeremy Rudin and Richard Knabl for excellent research assistance. We have also benefitted from the comments of E. Berndt, W.E. Diewert, M. Denny and C. Morrison but alone are responsible for any errors or omissions. The research reported here is part of the NBER's research program in Productivity. Any opinions expressed are those of the authors and not those of the National Bureau of Economic Research.

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ABSTRACT

In this paper we present for the first time estimates of cost and efficiency differences between U.S. and Japanese producers based on an econometric cost function methodology rather than the accounting frameworks previously used. We demonstrate that the cost difference estimates for 1979 which were influential in the debate that resulted in the Voluntary Restraints Agreements of 1981-85 were substantial overestimates of the Japanese advantage. While our estimate of the Japanese cost advantage for 1980 is similar to previous estimates, we attribute most of this advantage to short-run phenomena - underutilization of U.S. production capacity and an undervalued yen. In a previous paper we have shown that the Japanese TFP growth rate was much faster than the U.S. rate during the 1970's. However we estimate the long-run underlying Japanese efficiency advantage as of 1980 to have been only 1-2%, much less than previously estimated. This results from the fact that Japan began the 1970's with a long-run efficiency disadvantage of over 20%, and the decade of the 1970's represented a catch-up period for Japanese producers.

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1. Introduction

Published studies of the Japanese cost advantage in automobile production (Abernathy, Harbour and Henn (1981), Abernathy, Clark and Kantrow (1983), Federal Trade Commission (1983)) have estimated that Japanese manufacturers enjoyed a $1,500-$2,000 lower cost of producing an automobile compared with U.S. manufacturers during the 1979-80 period.[1] These studies also attributed a substantial portion of the cost advantage to superior efficiency characteristics of Japanese production processes. Studies of this type, especially Abernathy, Harbour and Henn (1981), were influential in the debate that resulted in the Voluntary Restraints Agreements (VRA) of 1981-85 which reduced significantly the supply of Japanese-produced automobiles available for purchase in the United States. They also played an important role in the F.T.C.'s approval of the General Motors-Toyota California joint venture in automobile stamping and assembly despite substantive anti-trust concerns.

The cost data contained in Abernathy, Harbour and Hein (1981) and Abernathy, Clark and Kantrow (1983) have been criticized by Gomez-Ibanez and Harrison (1982), Federal Trade Commission (1983), and Fuss and Waverman (1985b) as substantial overestimates of the Japanese cost advantage. The problems with these estimates include double-counting of U.S. cost data, ad hoc adjustments for vertical integration and product mix, and the inability to separate out factor price effects from efficiency effects and short-run phenomena from long-run underlying trends.

Many of the problems with these earlier studies arise because they are essentially accounting studies which do not employ rigorous methods of analysis. In this study we utilize an econometric cost function and the decomposition analysis proposed by Denny and Fuss (1983) to measure the extent and sources of cost and efficiency differences between U.S. and Japanese automobile producers. This methodology permits us to overcome two major shortcomings of previous studies - the inability to disentangle adequately factor price effects from efficiency effects, and the inability to account correctly for short-run disequilibrium.[2]

Short-run disequilibrium in the automobile industry is primarily due to variations in capacity utilization. The automobile industry is characterized by quasi-fixed factors such as capital plant and equipment and white collar labour and by product-specific manufacturing facilities. Hence swings in consumer tastes among different products can lead to variations in capacity utilization which greatly affect measured cost and efficiency differences. The shift to small cars in the U.S. after 1978, along with the downturn in the U.S. economy, left U.S. producers with substantial underutilized capacity, especially during 1980-83. Our empirical estimates suggest that while Japanese producers enjoyed a 34.4% unit cost advantage in 1980 - a number which is similar to previous estimates (e.g. Federal Trade Commission (1983)) - that advantage would have been reduced to 11.9% had U.S. producers attained the Japanese levels of capacity utilization. Similarly, according to our estimates, the Japanese efficiency advantage in 1980 was 22.4%, but this advantage would have fallen to 1.4% had U.S. producers been utilizing capacity at a normal (i.e. designed) rate.

The most striking feature of our empirical results is the extent to which we attribute the Japanese cost advantages of 6.7% in 1979 and 34.4%

in 1980 to short-run phenomena. At comparable "normal" capacity utilization rates in both countries, the Japanese cost advantage becomes 2.9% in 1979 and 11.9% in 1980. If we adjust factor prices to take account of the undervalued yen (relative to its purchasing power parity rate), then the U.S. would have actually had a cost advantage of 0.9% in 1979 and its 1980 disadvantage falls to 5.2%. On the other hand, underlying efficiency difference trends were not so favourable to U.S. producers. During the period 1970-80, long-run total factor productivity growth was 4.3% per annum in Japan and only 1.6% per annum in the U.S. (Fuss and Waverman (1985a)). This disparity is reflected in the current study by the fact that although during the period 1970-72 U.S. producers had a long-run efficiency advantage of 21.6%, by 1980 this advantage had become a 1.4% disadvantage. During the 1970's Japanese producers caught up to U.S. producers in efficiency of production. However, the large efficiency advantage attributable to Japanese producers by some earlier studies based on 1979 data is inconsistent with our results.

As noted above, our empirical results are obtained from an estimated cost function and a decomposition analysis. Sections 2 and 3 present the formal model underlying the empirical results. Included in Section 3 is a discussion of the way in which capacity utilization effects are captured through a somewhat novel application of the Viner-Wong envelope result. The specific empirical results are contained in Section 4. In Section 5 we conclude the paper with some summary remarks.

2. The Cost Function Approach to the Analysis of Cost and Efficiency Differences

2.1 Cost Comparisons - A Decomposition Analysis

Utilizing the duality between cost and production under the assumption of cost-minimizing behaviour, we specify that the automobile production process can be represented indirectly by the cost function

$$C_{it} = G_{it}(\underset{\sim}{w}_{it}, Q_{it}, \underset{\sim}{T}_{it}) \qquad (1)$$

where C_{it} is the total cost of production in country i at time t, $\underset{\sim}{w}_{it}$ is a vector of factor prices, Q_{it} is a scalar of output and $\underset{\sim}{T}_{it}$ is a vector of technological conditions which could be viewed as the "characteristics" of the production process. Examples of characteristics to be used in this study are an index of Research and Development expenditures (a proxy for technical change) and capacity utilization. The use of this characteristics approach was proposed by McFadden (1978) and has been applied to telecommunications [Denny, et al. (1981a, b)], trucking [Spady and Friedlaender (1978), Kim (1984)] and U.S. automobile production [Friedlaender, Winston and Wang (1983)]. The logarithm of the cost function (1) will be appproximated by a quadratic function in the logarithms of $\underset{\sim}{w}_{it}$, Q_{it}, $\underset{\sim}{T}_{it}$ and $\underset{\sim}{D}$; i.e.,

$$\log C_{it} = G(\log \underset{\sim}{w}_{it}, \log Q_{it}, \log \underset{\sim}{T}_{it}, \underset{\sim}{D}) \qquad (2)$$

where G is a quadratic function and $\underset{\sim}{D}$ is a vector of country-specific dummy variables. Applying the Quadratic Lemma[3] to (2) yields

$$\Delta \log C = \log C_{is} - \log C_{0t}$$

$$= \frac{1}{2}\left[\frac{\partial G}{\partial D_i}\Big|_i + \frac{\partial G}{\partial D_i}\Big|_0\right] \cdot [D_i - D_0]$$

$$+\frac{1}{2}\sum_k \left[\frac{\partial G}{\partial \log w_k}\Big|_{w_k=w_{kis}} + \frac{\partial G}{\partial \log w_k}\Big|_{w_k=w_{k0t}}\right] \cdot [\log w_{kis} - \log w_{k0t}]$$

$$+\frac{1}{2}\left[\frac{\partial G}{\partial \log Q}\Big|_{Q=Q_{is}} + \frac{\partial G}{\partial \log Q}\Big|_{Q=Q_{0t}}\right] \cdot [\log Q_{is} - \log Q_{0t}]$$

$$+\frac{1}{2}\sum_\ell \left[\frac{\partial G}{\partial \log T_\ell}\Big|_{T=T_{\ell is}} + \frac{\partial G}{\partial \log T_\ell}\Big|_{T=T_{\ell 0t}}\right] \cdot [\log T_{\ell is} - \log T_{\ell 0t}] \qquad (3)$$

where i indexes the country

t,s index the time period

k indexes the factors of production

ℓ indexes characteristics

$D_i = 1$ if the observation is in country $i \neq 0$

$= 0$ otherwise

and country 0 is the "reference" or "base" country. Assuming price-taking behaviour in factor markets and utilizing Shephard's Lemma, (3) can be written as

$$\Delta \log C = \frac{1}{2}\sum_k [S_{kis} + S_{k0t}][\log w_{kis} - \log w_{k0t}]$$

$$+ \frac{1}{2} \; [ECQ_{is} + ECQ_{0t}][\log Q_{is} - \log Q_{0t}]$$

$$+ \frac{1}{2} \sum_{\ell} [ECT_{\ell is} + ECT_{\ell 0t}][\log T_{\ell is} - \log T_{\ell 0t}]$$

$$+ \theta_{i0} \qquad (4)$$

where

$$\theta_{i0} = \frac{1}{2} \left[\frac{\partial G}{\partial D_i}\Big|_i + \frac{\partial G}{\partial D_i}\Big|_0 \right] \cdot [D_i - D_0] \qquad (5)$$

ECQ = elasticity of cost with respect to output

ECT = elasticity of cost with respect to the technological characteristic

For a particular point in time, t=s and equation (4) provides a decomposition of the index of average cost difference between countries i and o at time t:

$$\Delta \log (C/Q) = \frac{1}{2} \sum_{k} [s_{ki} + s_{ko}][\log w_{ki} - \log w_{ko}]$$

$$+ \frac{1}{2} [ECQ_i + ECQ_o - 2] \cdot [\log Q_i - \log Q_o]$$

$$+ \frac{1}{2} \; [ECT_{\ell i} + ECT_{\ell o}] \cdot [\log T_{\ell i} - \log T_{\ell o}]$$

$$+ \theta_{io} \qquad (6)$$

where the time subscript t has been suppressed for simplicity. Following Denny and Fuss (1980), the index of cost efficiency difference between countries i and o at any point in time is given by

$$CED_{i,o} = \Delta\log (C/Q) - \frac{1}{2} \sum_{k} [S_{ki} + S_{ko}][\log w_{ki} - \log w_{ko}] \qquad (7)$$

The expression for CED in equation (7) is just the dual formulation of the translog index of interspatial productivity difference introduced by Jorgenson and Nishimizu (1978).

Rearranging equation (7), we obtain an alternative equation for $\Delta\log (C/Q)$:

$$\Delta\log (C/Q) = \frac{1}{2} \sum_{k} [S_{ki} + S_{ko}] \cdot [\log w_{ki} - \log w_{ko}] + CED_{i,o} \qquad (8)$$

Combining (7) and (8) we obtain an expression for CED in terms of efficiency sources:

$$CED_{i,o} = \frac{1}{2} [ECQ_i + ECQ_o - 2] \cdot [\log Q_i - \log Q_o]$$
$$+ \frac{1}{2} \sum_{l} [ECT_{\ell i} + ECT_{\ell o}] \cdot [\log T_{\ell i} - \log T_{\ell o}]$$
$$+ \theta_{io} \qquad (9)$$

Equations (6), (8) and (9) provide the formulas for decomposing unit cost differences and efficiency differences into their various sources.

Consider equation (6). The left hand side is the average cost difference between two countries at a point in time. This difference is due to differences in factor prices (the first row on the right hand side), the effects of scale economies (the second row), the effects of technological characteristics (the third row) and θ_{io} (the fourth row). The term θ_{io} measures any systematic cost difference between the two countries not accounted for by factor prices, scale, and technology. It will be called the country-specific efficiency effect, and is presumably a combination of managerial and environmental effects.

Now consider equation (8). The average cost difference between the two countries is due to differences in factor prices (the first term), and differences in cost efficiency (the second term). Finally consider equation (9). The cost efficiency difference between two countries is due to scale effects (the first row), technological effects (the second row) and country-specific efficiency differences (the third row).

2.2 Specification and Estimation of the Econometric Cost Function

The cost function (1) is approximated by a translog (quadratic) function of the form (2). Writing out (2) in detail for the i-th country yields

$$
\begin{aligned}
\log C_{it} = {} & \alpha_o + \alpha_{oi} D_i + \sum_k (\alpha_k + \alpha_{ki} D_i) \log w_{kit} \\
& + (\beta_1 + \beta_{1i} D_i) \log Q_{it} \\
& + \sum_\ell (\theta_1 + \theta_{\ell i} D_i) \log T_{\ell it} \\
& + \frac{1}{2} [\sum_k \delta_{kk} (\log w_{kit})^2 + \mu_{11} (\log Q_{it})^2 \\
& + \sum_\ell \phi_{\ell\ell} (\log T_{\ell it})^2] \\
& + \sum_k \sum_{\substack{m \\ k<m}} \delta_{km} \log w_{kit} \log w_{mit}
\end{aligned}
$$

$$+ \sum_{\substack{\ell \\ \ell<p}} \sum_{p} \phi_{\ell p} \log T_{\ell it} \log T_{pit}$$

$$+ \sum_{k} \lambda_{k1} \log w_{kit} \log Q_{it}$$

$$+ \sum_{k} \sum_{l} \lambda_{kl} \log w_{kit} \log T_{lit}$$

$$+ \sum_{\ell} \tau_{\ell\ell} \log Q_{it} \log T_{\ell it} \qquad (10)$$

Utilizing Shephard's Lemma results in the cost share equations

$$S_{kit} = \alpha_k + \alpha_{ki} D_i + \delta_{kk} \log w_{kit} + \sum_{m \neq k} \delta_{km} \log w_{mit}$$

$$+ \lambda_{k1} \log Q_{it} + \sum_{\ell} \Lambda_{k\ell} \log T_{\ell it} \qquad k = 1,\ldots,K \qquad (11)$$

Estimates of the parameters of the system are obtained by estimating simultaneously (using maximum likelihood techniques) the cost function (10) and $K-1$ equations from (11), imposing the constraints

$$\sum_{k} \alpha_k = 1, \quad \sum_{k} \alpha_{ki} = 0, \quad \sum_{m} \delta_{mk} = 0, \quad \delta_{mk} = \delta_{km},$$

$$\sum_{k} \lambda_{k1} = 0, \quad \sum_{k} \Lambda_{k1} = 0, \quad \sum_{k} \alpha_{ki} = 0, \quad \phi_{\ell p} = \phi_{p\ell} \qquad (12)$$

3. Incorporating Capacity Utilization Effects into the Cost Function - An Application of the Viner-Wong Envelope Theorem

As noted in the introduction, the automobile industry is characterized by quasi-fixed factors and yearly fluctuations in demand for its products. These features result in variations in capacity utilization which cannot be captured by a long-run equilibrium model. There are two possible approaches to this problem. First, a variable cost function with exogenous quasi-fixed factors could be specified and capacity utilization rates determined endogenously. An example of such an approach is Berndt and Fuss (1986). Second, capacity utilization, rather than the quasi-fixed factors, could be treated as exogenous. In this case the demands for quasi-fixed factors are determined endogenously.[4] An example of this second approach is Cowing, Small and Stevenson (1981). While we intend to pursue the first approach in subsequent research, in this study we adopt the second approach. This particular approach is likely to be successful when plants are designed, ex ante, to produce a "normal" flow of output which can be relatively easily measured. The major components of the automobile industry-vehicle assembly and the manufacture of engines, transmissions and transaxles satisfy this requirement.[5] Specifying capacity utilization rather than the levels of quasi-fixed factors as exogenous from the point of view of the model has two advantages. One, the identity of the quasi-fixed factors does not need to be determined a priori. Two, the analysis can proceed without the assumption that the quasi-fixed factors are fixed in the short run.[6]

The approach adopted in this paper can be linked to the short-run optimization problem faced by the firm in the presence of quasi-fixed factors, and hence quasi-fixed capacity output. The firm is assumed to minimize the cost of producing actual output observed from a flow of factor services (unobserved) generated from the quasi-fixed stocks of factors. The per unit prices of these services are unobserved shadow prices, depending on the actual market price of the stocks and the relationship between actual and capacity output. The higher is actual output, the lower are the shadow prices of factor services from quasi-fixed inputs, since the fixed costs of the stocks are spread over more units of output (and hence more units of inputs). The unobserved variables are linked to observed variables by the fact that the total cost of a particular factor, whether it be an unobserved flow or an observed stock, is always observed. The mathematical details can be found in Fuss and Waverman (1985b).

The existence of capacity utilization as an argument of the cost function implies that the output argument should be capacity output. Capacity output should be thought of as that flow of output per unit time which is viewed as "normal" by the firm, in the sense that if the output flow is sustained over time the firm has no incentive in the long run to adjust the levels of its quasi-fixed factors. Normal capacity utilization then occurs when actual and designed (normal) output flows per unit time are equal.

Output increases which affect unit costs can occur in two ways. Existing capacity can be utilized more intensively, or capacity can be increased, utilization held constant. In this setting the Viner-Wong envelope result between short-run and long-run average costs (Viner (1952)) implies a set of constraints on the parameters of the translog cost function for envelope consistency to be maintained.

Fuss and Waverman (1985a) show that envelope consistency is maintained if the cost-capacity output and cost-capacity utilization elasticities satisfy the following relationships:

$$\begin{aligned} &ECT_1 = ECQ, \text{ normal capacity utilization} \\ &ECT_1 < ECQ, \text{ below normal capacity utilization} \\ &ECT_1 > ECQ, \text{ above normal capacity utilization} \end{aligned} \tag{13}$$

where ECT_1 is the cost-capacity utilization elasticity and ECQ is the cost-capacity output elasticity.

Fuss and Waverman (1985a) also demonstrate that, if the capacity utilization rate is normalized so that it equals unity when capacity and actual outputs are equal, then the envelope consistency conditions (13) imply the following constraints on the parameters of the translog cost function:

$$\begin{aligned} &\theta_1 = \beta_1 \\ &\theta_{1i} = \beta_{1i} \\ &\phi_{1\ell} = \tau_{1\ell} \qquad \ell \neq 1 \\ &\Lambda_{k1} = \lambda_{k1} \\ &\tau_{11} = \mu_{11} \end{aligned} \tag{14}$$

When the equalities (14) are imposed, $ECT_1 - ECQ = (\phi_{11} - \tau_{11}).\log T_1$. Hence for the envelope inequality in (13) to hold, it must be the case that $\phi_{11} > \tau_{11}$.

Unfortunately, imposition of the envelope consistency constraints renders the second order translog function less flexible than is desired.[7] Since $\frac{\partial S_k}{\partial \log T_1} = \Lambda_{k1} = \lambda_{k1} = \frac{\partial S_k}{\partial \log Q}$, factor cost shares change to the same extent when output increases, independent of whether the output increase is due to increased capacity utilization or increased capacity. Given the quasi-fixed nature of capital, capital cost shares should decline (and other input cost shares rise) when capacity utilization increases relative to when capacity increases. To permit this possibility, third order terms must be added to the cost function. A parsimonious, sufficiently flexible specification is obtained by adding terms of the form

$$\frac{1}{6} \sum_{k} \sum_{i=1} \sum_{j=1} \rho_{kij} \log w_k \log T_i \log T_j$$

$$= \frac{1}{2} \sum_{k} \rho_{k11} \log w_k (\log T_1)^2 \qquad (15)$$

to the cost function. As a result of (15), a term of the form

$$\frac{1}{2} \rho_{k11} (\log T_1)^2 \qquad (16)$$

is added to the k-th cost share equation.

The addition of (15) to the cost function implies that the allocation formulas of section 2 must also be altered. By applying the theoretical framework developed by Denny and Fuss (1983), it can be shown that an interaction term of the form

$$\frac{1}{2} \sum_{k} \rho_{k11} [\log w_{ki} - \log w_{ko}].[\log T_{1i} - \log T_{1o}]^2 \qquad (17)$$

must be added to the right hand side of the decomposition formulas (6) and (9). Finally, the condition required for the envelope inequality in (13) to hold becomes

$$\phi_{11} + \sum_k \rho_{k11} \log w_k > \tau_{11} \tag{18}$$

4. Empirical Results

4.1 Cost Function Estimation

The cost function was estimated using annual pooled three digit SIC automobile production data (vehicle assembly + parts production) from Canada (1961-80), United States (1961-80) and Japan (1968-80). The exogenous variables were specified as follows:

input prices (K=3) - capital (1); materials (2); labour (3)

output - constant dollar capacity (normal or designed) production of vehicles and parts

technological conditions (L=3) - capacity utilization (1); technological change proxy index-index of real stock of R & D expenditures (2); index of product mix (3)

A description of the data used to construct these variables is contained in the Data Appendix.

Equations (10 + 15) and (11 + 16) were estimated, with constraints (12) and (14) imposed, using the Zellner iterative technique to obtain maximum likelihood estimates. Initial estimation results implied that the regularity conditions for the cost function were not satisfied at a number of data points. The cost function was not concave for Canada (16 observations) and non-monotone in the technical change index (Canada (9 observations) and U.S. (4 observations)). The minimal parameter constraints necessary to ensure local regularity over the sample were imposed.[8] In the case of the concavity constraints, this implied different second order parameters $\delta_{11,c}$, $\delta_{33,c}$, $\delta_{12,c}$, $\delta_{13,c}$ and $\delta_{23,c}$ for Canada. Since the regularity constraints are not nested in the basic specification, no formal testing was undertaken. However, the imposition of the constraints led to only a moderate decline in the log-likelihood function (from 545.17 to 536.29).

One additional set of constraints was imposed on the parameters. As described in more detail in Fuss and Waverman (1985b), the product mix variable (T_3) was computed as an index where typical weights are assigned to different classes of automobiles (sub-compact, compact, intermediate, etc.) and an average weight for actual production computed. This variable fluctuated fairly tightly around 2500 for Japan and 3500 for Canada and U.S. Hence it almost served as a dichotomous dummy variable for Japan versus North America. From initial estimation results it became clear that second order parameters involving T_3 could not be estimated and were set to zero. This had the effect of constraining the cost-product mix elasticity to be a constant over time for each country, although the elasticity could differ among countries.

The lengthy list of parameter estimates are not presented due to space limitations. These parameter estimates, along with asymptotic standard errors and the usual diagnostic summary statistics can be found in Fuss and Waverman (1985a). However, in order that the reader have some feel for the estimated production structure, Tables 1 and 2 present estimates of factor price elasticities, elasticities of substitution and other elasticities of interest.

Using the parameter estimates we verified that the inequality condition (18) required by envelope consistency is satisfied at each data point in the sample. The importance of including the third order capacity utilization terms is readily evident from the empirical results. Each of the parameters ρ_{k11}. k=1,2,3 is statistically significant, and the ones relating to capital and labour substantially so. The signs of the parameters are the correct ones, indicating that as underutilized capacity is utilized more intensively, the cost share of capital declines and the cost shares of labour and materials increase.

Table 2 demonstrates that production in both the U.S. and Japan is subject to increasing returns to scale at the mean data point. The capacity utilization elasticity shows that costs increase proportionately less than actual output, (designed output held constant) so that there are short-run economies of fill. Any increase in research and development expenditures appears to have more of a cost-reducing impact in Japan than in the U.S., although since the elasticities vary with the data, this cannot be determined for certain from the mean elasticities.

The cost-product mix elasticities are very small. This is not surprising since the output variable has been calculated from value and price data so that it is denominated in "standard" units (see Fuss and Waverman (1985b) for details concerning the construction). If the long-run marginal cost of producing a vehicle is proportional to category weights,[9] then the cost-product mix elasticity would be zero. If there are economies of scale (i.e., non-proportionality) in producing larger (heavier) automobiles then the elasticity would be negative.

4.2 <u>The Extent and Sources of Cost and Efficiency Differences</u>

In this section we present the empirical results on cost and efficiency level comparisons between the United States and Japan using equations (6), (8), and (9), as modified in Section 3. The results are presented in Tables 3 - 11. Table 3 contains the percentage unit production cost differences (in a common currency) between U.S. and Japanese automobile producers over the 1970 to 1980 period. The production cost difference for the periods 1970-72 and 1977-79 are three year averages. The first column in Table 3 indicates that the U.S. automobile unit production cost was 8.5% higher in the 1970-72 period than the Japanese unit cost. This disadvantage declined to less than 1% by 1977-79. However in 1980 there was a rapid deterioration in the U.S. position, leading to the result that the Japanese advantage rose sharply to 34.4%. This table also presents the conventional "sources of difference" percentages obtained from ratios of logarithmic derivatives. This method of decomposition has the advantage of showing explicitly the interaction effect, but the very large percentages in the sources of difference cells make interpretation very difficult. We believe it is more interesting to consider the discrete comparative statics analysis which results from varying the exogenous variables one at a time, holding all other exogenous variables constant. Such an analysis is contained in Table 4 and all subsequent decomposition tables other than Table 7.

The numbers in the cells under the "Sources of Difference" columns in Table 4 have the following interpretation. The number 27.2 under the column "Price of Labour" in the first row of Table 4 implies that if all variables affecting costs, <u>other than the price of labour</u>, were equal in the two countries at the geometric average of their values in the two countries in the years 1970, 1971 and 1972, then unit production cost in the United States would have been 27.2% higher than in Japan (due to the actual differences in labour prices). Similarly, the number -15.2 under the column "Country Specific Efficiency" implies that if all variables except the technical change variable and the country dummy variable had been equal in the two countries, unit production costs would have been 15.2% lower in the United States than in Japan during the 1970 to 1972 period. In the Data Appendix we argue that the technical change variable is properly viewed as a method of tracking the country-specific unexplained technical change. From this point of view consistency requires that we aggregate the technical change effect with the country specific efficiency effect into a single decomposition effect which we will call the country-specific efficiency effect. That is what has been done in creating the tables in this section.

The specific sources of the production cost advantage to Japan demonstrate that there were two primary effects (at least through 1979) which worked in opposite directions. First, factor price advantages to Japan declined sharply over this period. For example, if only the price of labour differed between the two countries, the Japanese advantage would have been 27.2% with respect to unit production costs in 1970-72 and only 13.0% in 1979. If only the price of materials differed between the two countries, a Japanese cost advantage of 16.5% in 1970-72 would have changed to a 3.9% disadvantage by 1979. On the other hand, had all prices of factors of production, output levels, product mix, and capacity utilization rates been the same in the two countries, Japanese production costs, relative to those in the U.S., would have been 15.2% <u>higher</u> in 1970-72 and 1.5% <u>lower</u> in 1979. This result is consistent with the finding in Fuss and Waverman (1985a) that during the 1970-80 period long run productivity growth was 4.3% per annum in Japanese automobile production and only 1.6% per annum in U.S. auto production.

The year 1980 was a year in which all major sources of cost differences moved against the United States. The major source of the sharp increase in the Japanese unit cost advantage can be attributed to the deterioration in relative capacity utilization in North American auto production.

It is instructive to isolate changes in cost differences which are due to exchange rate fluctuations from those due to relative movements in factor prices and efficiencies within each country, since exchange rate fluctuations can be viewed as a source of short-run disequilibrium. To do so, we need to establish "standard" exchange rates to measure fluctuations around, and we need to adjust the allocation formulae so that fluctuations of the exchange rate around this standard rate becomes another source of unit cost differences. We established "equilibrium" exchange rates based on the concept of a fundamental equilibrium exchange rate (FEER) as calculated by Williamson (1983). The FEER's between Japan and the U.S. were combined with relative rates of price inflation (as measured by wholesale price indices) to produce purchasing-power parity currency exchange rates, denoted the "equilibrium" rates. A comparison of costs calculated at the equilibrium rates with those calculated at actual exchange rates provides a measure of the cost difference attributable to exchange rate fluctuations away from the equilibrium rates. Table 5 presents the actual and equilibrium exchange rates between U.S. and Japan for the period 1977-80. Earlier data could not be obtained since Williamson did not calculate FEERs before 1977. Details of the calculation and the methods for adjusting the allocation formulae are contained in Fuss and Waverman (1985b).

The result of this adjustment is to provide factor price effects which measure cost differentials when factor prices are computed at equilibrium exchange rates.

We now turn to Table 6 which separates out the exchange rate fluctuation effect. The interpretation of this table is as follows. The number 12.8 under the heading "Price of Labour" implies that had the U.S.-Japanese exchange rate been at its purchasing power parity or equilibrium level during 1977-79, and all effects other than the price of labour been equal between the two countries, unit production cost would have 12.8% higher in the U.S. than in Japan. The number 4.3 under the heading "Exchange Rate Fluctuation" means that had all factors affecting cost differences been the same in the two countries, where factor prices are evaluated at the equilibrium exchange rate, unit production cost would have been 4.3% higher in the U.S. than in Japan in 1977-79 due to exchange rate fluctuation away from the equilibrium exchange rate. From Table 6 it can be seen that the sharp rise in the U.S. production cost disadvantage between 1979 and 1980 was partially caused by a devaluation of the yen relative to its equilibrium value (see Table 5). As noted earlier, the major determinant of this increase was the capacity utilization effect. Comparing Tables 4 and 6, we see that the apparent worsening of relative capital and materials prices, from the U.S. point of view, was an exchange rate phenomenon. Table 6 demonstrates that U.S. production costs, relative to Japanese production costs, were higher throughout the 1977-80 period partially due to a Japanese yen which was devalued relative to its equilibrium level.

Tables 7 and 8 present cost efficiency differences (CED) between U.S. and Japanese auto production. Table 7 presents the conventional sources of differences accounting, analogous to Table 3 previously discussed. It is included to indicate the magnitude of the interaction effect. Table 8 presents the comparative statics analysis analogous to Table 4. We will concentrate on Table 8. The most striking feature of Table 8 is the very substantial deterioration in U.S. cost efficiency relative to the Japanese cost efficiency over the 1970-80 period. From this table we can see that in the 1970-72 period the United States had a cost efficiency advantage over Japan of the order of 20%. This deteriorated throughout the period. By 1979 Japan had caught up to the U.S. This adverse inter-temporal effect was due almost entirely to a deterioration in the U.S. country-specific efficiency versus the Japanese country-specific efficiency. In the 1970-72 period, had country-specific efficiency been the only source of cost efficiency difference between the two countries, the U.S. would have had a 15.2% advantage. By 1979 this advantage would have switched to a 1.5% disadvantage. The jump in the U.S. cost efficiency disadvantage between 1979 and 1980 from 0.3% to 20.6% is caused partially by an increased disadvantage in U.S. country-specific relative efficiency, but is caused mainly by the capacity utilization effect discussed earlier.

Although as we have seen in the above tables, exchange rate fluctuations and variations in capacity utilization can have important impacts on the relative levels of unit production costs and cost efficiency, for many purposes it is more important to look at the long run underlying trends in these cost differences. We can do this by setting the levels of capacity utilization equal to normal capacity utilization rates and by setting exchange rates at their equilibrium levels. Table 9(a) presents unit production cost differences and the sources of these differences when capacity utilization rates are normal. Table 9(b) presents analogous information when, in addition, exchange rates are equilibrium rates. We call these cases equilibrium cases and present two versions since the calculations leading to equilibrium exchange rates are inherently subjective calculations over which reasonable observers may disagree. Because we do not have equilibrium exchange rates earlier than 1977, we can only consider the 1977 to 1980 period for the second version (Table 9(b)). From Table 9(a) we see that U.S. producers began and ended the 1970's with a production cost disadvantage, at normal capacity utilization rates. The changes in unit production cost differences over this period were not as large as the changes in the sources. For the U.S., favourable movements in factor prices were offset by unfavourable movements in relative efficiency. However, during the 1977-80 period both a worsening of factor price effects and cost efficiency effects contributed to the U.S. relative decline in equilibrium unit cost. Table 9(b) tells essentially the same story for 1977-80 (when adjustments are also made for exchange rate fluctuations). It is striking to note that while U.S. producers had a

34.4% actual unit cost disadvantage in 1980 (Table 6), the equilibrium unit cost disadvantage in that year was only 11.9% or 5.2%, depending on the equilibrium calculation. This result demonstrates the substantial influence on relative inter-country production costs of short-run phenomena such as variations in capacity utilization and exchange rate fluctuations.

In summary, although in 1980 U.S. producers suffered large actual cost disadvantages relative to Japanese producers, their underlying equilibrium situations were much more favourable, due primarily to lower capital and materials prices. Offsetting these U.S. advantages were higher labour prices and marginally less efficient production processes.

Table 10 decomposes the cost efficiency difference displayed in Table 9. From Table 10 we see that a U.S. underlying advantage of 21.6% in the 1970-72 period had become a disadvantage of 1.4% by 1980. This large reversal of U.S. fortunes was the result primarily of a substantial deterioration in the U.S. country-specific efficiency effect, and a smaller deterioration in the U.S. advantage due to scale economies.

5. Conclusions

The results presented in this study go a long way towards clarifying the Japanese competitive threat to U.S. automobile production. A Japanese relative cost advantage vis a vis U.S. producers is not a recent phenomenon. U.S. producers began the decade of the 1970s with a unit production cost disadvantage. The cost disadvantage at that time was due primarily to the existence of lower factor prices in Japan since U.S. producers enjoyed a large efficiency advantage over Japanese producers. However by the end of the decade the U.S. efficiency advantage had disappeared, to be replaced by a small efficiency disadvantage (at normal capacity utilization rates).

Our results also shed light on the very large actual unit production cost increases in the United States between 1979 and 1980 which led to quotas on Japanese imports beginning in 1981. To some extent, these production cost increases reflected a continuing deterioration in the U.S. position with regard to long run efficiency differences. However the bulk of the sharp change in U.S. fortunes could be attributed to cyclical phenomena. The very low levels of capacity utilization experienced in 1980 in the U.S. and (to a lesser extent) the devaluation of the Japanese yen relative to its equilibrium level were major causes of the cost deterioration. Cost competitive problems caused by low levels of capacity utilization are not really a reflection of inappropriate production techniques in some long run sense. The major problem faced by North American producers was the fact that these producers could not sell as many cars as their plants were designed to produce. In 1980 the primary place where North American producers could not compete with the Japanese was in the design of automobiles with appropriate quality and size characteristics, rather than in relative production costs.

In the 1980s U.S. producers took the steps that this study has determined were necessary to become more cost-competitive: they closed a number of plants and shifted the product mix produced in the remaining plants toward a higher proportion of small automobiles. Both adjustments improved capapcity utilization, the major source of the U.S. cost disadvantage. In addition, U.S. producers began implementing Japanese production techniques in order to blunt the Japanese total factor productivity growth advantage which had so severely eroded the U.S. cost efficiency advantage that existed in the early 1970s.

Finally, it is useful to compare our results on United States-Japan unit cost differences with the earlier studies discussed in the Introduction. Table 11 presents the relevant data, where the Japanese dollar cost advantage calculated by other studies has been put into percentage form so that it can be compared with our results.

As expected from our earlier discussion, Abernathy et al (1981, 1983) substantially overestimate the Japanese cost advantage in 1979, whereas the Federal Trade Commission (FTC) results are relatively close to ours.[10] A comparison of the results for 1980 shows once again the importance of decomposing any observed cost advantage into its underlying causes. Failure to do so will often lead to confusion between short run effects (in this case capacity utilization variations and fluctuations in exchange rates) and longer run underlying effects due to secular movements in factor prices and cost efficiency (productivity) levels.

The U.S. automobile industry was not in some fundamental cost crisis during 1979-80 from which it could not recover, as some earlier studies have suggested. At the same time however the long-run trends in relative efficiency levels were not favourable to U.S. producers and required corrective action, action which was begun during the early 1980s.

FOOTNOTES

1. Abernathy, Clark and Kantrow (1983) present 1981 estimates, but these are based primarily on 1979 data extrapolated to 1981.

2. Since we use 3 digit SIC aggregate data rather than individual company data, double counting of U.S. cost data alone does not occur. No adjustment for differing degrees of vertical integration is necessary since, while this will result in different capital, labour and materials factor intensities in the two countries even if they fact the same factor prices, our econometric model specification allows for this possibility.

3. For a description of the Quadratic Lemma see Diewert (1976) and Denny and Fuss (1983). The specific decomposition formula (3) can be found in Denny and Fuss (1980) and Denny, Fuss and May (1981).

4. Of course neither quasi-fixed factors nor utilization rates are truly exogenous to the firm's decision process. What is meant by "exogenous" in this context is that the observed variables are not in long-run equilibrium; i.e., the levels of quasi-fixed factors are not necessarily chosen to equate the marginal rate of factor substitution to the current ratio of factor prices, and the rate of actual output flow is not necessarily equal to the designed (or normal) rate of flow.

5. See Miller and Bereiter (1985) for a discussion of the case of vehicle assembly.

6. The main disadvantage of the approach taken in this paper is that the only disequilibrium feature which can be captured is the

deviation of actual from designed output. While this is by far the most important source of disequilibrium in the automobile industry, disequilibrium due to fluctuations in factor prices can only be captured by the variable cost function model.

7. This problem is similar to the one encountered when separability restrictions are imposed on the translog functional form (Denny and Fuss (1977)).

8. The constraints were minimal in the sense that the concavity condition was satisfied over the complete sample with only one data point (Canada, 1974) being subject to a binding constraint. Similarly, the monotonicity conditions were satisfied with only two binding constraints (Canada, 1961 and U.S., 1961). To some extent this result was fortuitous since no formal inequality restrictions algorithm was attempted. For an example of the use of such a formal procedure, see Hazilla and Kopp (1985).

9. This is a fact widely believed in the industry.

10. The FTC strict and liberal weight results bracket our results, with our results being somewhat closer to the FTC liberal weights version. This fact provides support for the FTC's contention that the liberal weights analysis is closer to the correct analysis. The difference between the strict and liberal weights versions depends on the interpretation of the way in which Japanese automobiles compete with U.S. autos, and the value to consumers of the additional weight of U.S. produced autos. For more details, see FTC (1983) or Fuss and Waverman (1985b).

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APPENDIX: DATA SOURCES AND METHODS OF DATA CONSTRUCTION

In this Appendix we present a brief description of the data sources and methods of data construction. More extensive descriptions can be found in the Data Appendix to Fuss and Waverman (1985a) and especially Chapter 4 of Fuss and Waverman (1985b).

A.1 General Sources of Data

The major source of data was the Annual Surveys (or Census) of Manufacturers in each country, which provided data on motor vehicles production at the 3 digit SIC level.

Nominal gross output was computed as the sum of value added plus cost of materials and converted to real output by applying the appropriate price deflators available in the U.S.A. from the Bureau of Industrial Economics, and in Japan from the Bank of Japan.

Three inputs are assumed to be used as factors of production - materials, labour and capital. Materials price deflators were available for both countries. The total compensation (rather than just the money wage) of labour has been calculated. Hours worked were estimated for production and non-production workers for the U.S. but not for Japan where the total number of workers was not disaggregated. Real capital stock data were available for the U.S. (Levy and Jondrow (1983)), but had to be estimated for Japan using data from the Annual Census and the perpetual inventory method.

The appropriate price of capital for our purposes is the ex ante user cost of capital services. The automotive industry-specific capital service price series which were available for the U.S. had been estimated by the residual method, which is an inappropriate ex ante measure for such a highly cyclical industry. We have instead utilized a user cost of capital series for U.S. total manufacturing (which would not be subject to such cyclical variations) presented in Norsworthy and Malmquist (1983). This series is available only to 1977 and was updated to 1980 using internal U.S. Bureau of the Census capital service price data. The capital service price for Japan is an extrapolation of the series for Japanese total manufacturing also presented in Norsworthy and Malmquist (1983). That series was available through 1978. Our extrapolation involved using the change in the Japanese prime interest rate beyond 1978 (DRI Japan Survey) and the changes in the price deflator for plant and equipment for Japanese manufacturing. (Source: Price Indexes Annual).

Capacity utilization rates were calculated from data for vehicle assembly. Maximum (potential) output was measured in the U.S. as the maximum weekly nameplate output and in Japan as the maximum monthly output. The "normal", or designed, capacity utilization rate was defined as the average utilization rate (ratio of actual to maximum output) for Japan over the period 1969-80. Actual capacity utilization rates were normalized so that this average rate was equal to unity. Capacity (normal) output was defined as the actual output divided by the normalized capacity utilization rate.

We have estimated a technological change indicator - the 'capital stock' of Research and Development. This stock is constructed by converting annual R & D expenditures to a real capital stock utilizing the perpetual inventory method, the country-specific CPI, and a depreciation rate of 15%. Our data on R & D expenditures for Japan began in 1966. Therefore, we needed a benchmark R & D stock. We assumed that in 1966 the technology available to Japan could be represented by the R & D stock per automobile produced in North America. We multiplied this value by the automobile production is Japan in 1966 to arrive at our benchmark. Since automobile production in Japan in 1966 was quite small relative to North America, the above procedure assigns a small value to the technical change index to Japan in 1966. Because of the way in which the R & D index was constructed, it has only a tentative link to the effect of R & D expenditures on costs. We believe it is more properly viewed as a method of tracing the country-specific unexplained technical change. From this point of view, the variable is similar to a time trend and was utilized because it consistently outperformed a time trend in the regression analysis.

A.2 Construction of Inter-Country Price Level Comparisons

The output price deflators used to convert nominal into real output are indices which are normalized to be unity in a particular year for each country. The same normalization occurs for materials and capital services prices.

In order to obtain inter-country level comparisons of cost and efficiency, benchmark prices must be calculated in a particular year to bridge the individual country price indices. In the following three sections we discuss the calculation of the benchmark data. We begin with the inter-country output price deflator.

A.3 Calculation of the Inter-Country Output Price Deflator

We used 1979 as the benchmark year for output price comparisons because detailed price data for Japan and the United States was available for 1979 from F.T.C. (1983). We first categorized all automobile production in the two countries into twelve categories. These categories were standard and luxury automobile versions of each of: mini, sub-compact, compact, mid-size, full-size and large. Average wholesale prices for each of these twelve categories were calculated in a manner described below, and translog relative aggregate price indices were calculated from the price and quantity data on the twelve categories.

Calculation of price data for the twelve individual categories was problematic because there existed no production data in a number of categories for at least one of the countries. Thus it was necessary to create price prediction equations which would predict the price that would have existed in a particular country had the automobile of the particular class actually been produced in that country. Price prediction equations were formed by using relatively simple hedonic-like price relationships between price and category·weight (FTC (1983)).

The price prediction equations were estimated from observations on individual models of automobiles. Consumer Reports (1979) was used to obtain information on automobile retail prices, classification information, and typical retail/wholesale margins for automobiles sold in the United States. Retail prices and category weights for Japanese-produced automobiles was kindly provided by M. Ohta from his unpublished database.

Finally, to complete the benchmark construction, we assumed inter-country relative prices of all automobile products other than automobiles in 1979 were in the same proportion as the comparable average automobile price.

A.4 Calculation of the Inter-Country Service Price of Capital Data

The benchmark for the capital service price was constructed as follows. We computed the real gross return to capital in each year for the two countries using the residual method (excluding 1980 for the U.S). The year in which the real return per unit capital most closely approximated the average real return over the sample for each country (1976) was determined. For that year the residual return was assumed to be the user cost of capital services.

For each country the user cost of capital for other years was obtained by linking the national cost of capital index to the benchmark year. The above procedure contains an implicit assumption and an implication. The assumption is that the returns to scale elasticities are equal across the countries so that no adjustment to the residual method is require. Our empirical results indicate that this assumption is essentially satisfied. The implication is that the user cost of capital for a particular country contains any excess (long run average) profits which result from the exercise of market power by firms in the automobile industry.

A.5 Calculation of the Inter-Country Materials Price Data

There exists no direct source of U.S.-Japan materials price comparisons. We constructed a U.S.-Japan comparison for 1974 in the following way. Toder (1978) presents data on relative U.S.-Japan prices of non-automotive materials for 1974. To obtain a price comparison of the intra-country, intra-industry materials flow in 1974, we assumed that the relative price was proportional to the relative industry output price. The relative shares of inter and intra industry material flows for the U.S. can be obtained from census data. We utilized 1977 U.S. census data to obtain the required weights.

A.6 Calculation of the Product Mix Variable

Japanese automobile producers produce a much larger proportion of small automobiles than do U.S. producers. If there are economies of producing large automobiles, where automobiles are measured in standard units (as is done in this study), then a variable which would control for this effect is required. All U.S. and Japanese automobile production over the sample period used in the estimation was divided into the six size class categories discussed in Section A.2. Each of these categories was assigned a category weight corresponding to the classification in F.T.C. (1983). For the U.S., average category weights were computed by finding the weighted average of the production of the various size classes from actual production figures. This average weight number will increase when the number of large cars produced increases and decline when the proportion of large cars produced declines. For Japan a slightly more complicated procedure was adopted. Detailed production data were available only for the years 1978-80. For all other years individual production data by models were not available. However, production data by cylinder size category were available for all years from JAMA Motor Vehicle Statistics. The detailed Japanese automobile data described above which was used in the construction of an output price index was also used to preduct weight categories from cylinder size categories by regressing category weight on cylinder size. The details of this calculation are contained in Fuss and Waverman (1985b). Data for 1978 and 1979 were computed by both methods to be certain that the margin for error in the indirect calculation of category weights was not too large. The margin of error was in the range of 2% and was deemed satisfactory.

TABLE 1a
Factor Own Price Elasticities
(computed at the mean data point for each country)

Input	United States	Japan
Capital	-0.33	-0.40
Materials	-0.17	-0.17
Labour	-0.53	-0.42

TABLE 1b
Elasticities of Substitution (Allen-Uzawa)
(computed at the mean data point for each country)

Inputs	United States	Japan
Capital-Materials	0.35	0.52
Capital-Labour	0.58	0.47
Labour-Materials	0.67	0.48

TABLE 2

Cost-Output Elasticities, Scale Elasticities, Capacity Utilization Elasticities, Technical Change Elasticities, and Product Mix Elasticities

(computed at the mean data point for each country)

Elasticity	United States	Japan
Cost-Output	0.93	0.92
Scale	1.07	1.09
Cost-Capacity Utilization	0.82	0.92
Cost-Technical Change	-0.24	-0.35
Cost-Product Mix	0.02	-0.02

TABLE 3

Unit Production Cost Difference and Its Sources - United States - Japan

Time Period	Unit Production Cost Difference (%)*	SOURCES OF DIFFERENCE (% Contribution)								
		Price of Labour	Price of Capital	Price of Materials	Product Mix	Scale Economies	Capacity Utilization	Country Specific Efficiency	Interaction	Estimation Residual
1970-72	8.5	293.0	-90.5	187.3	0.0	-109.2	32.7	-182.1	-13.0	-18.3
1977-79	0.6	2150.4	-704.4	-970.0	0.2	-800.9	189.7	-14.5	-31.4	252.0
1979	6.7	185.3	-47.0	-60.8	0.0	-65.0	42.9	34.2	-7.4	17.7
1980	34.4	49.3	-9.5	-8.2	0.0	-12.0	57.1	35.9	-17.7	5.2

* $\frac{\text{U.S.}}{\text{Japan}} \times 100$

TABLE 4

Unit Production Cost Difference and Its Sources - United States - Japan

Time Period	Unit Production Cost Difference (%)*	SOURCES OF DIFFERENCE (% Contribution)						
		Price of Labour	Price of Capital	Price of Materials	Product Mix	Scale Economies	Capacity Utilization	Country Specific Efficiency
1970-72	8.5	27.2	-7.0	16.5	0.0	-8.5	3.3	-15.2
1977-79	0.6	13.5	-4.0	-5.5	0.0	-4.6	1.2	-0.2
1979	6.7	13.0	-3.0	-3.9	0.0	-4.2	3.1	1.5
1980	34.4	17.1	-2.5	-2.4	0.0	-3.5	21.9	2.5

* $\left(\frac{\text{U.S. Cost}}{\text{Japan Cost}} - 1\right) \times 100\%$

Table 5

ACTUAL AND EQUILIBRIUM EXCHANGE RATES 1977-80

Year	Actual Exchange Rate (Yen/$)	Equilibrium Exchange Rate (Yen/$)
1977	267	236
1978	208	217
1979	218	210
1980	225	212

TABLE 6

Unit Production Cost Difference and Its Sources, Including Exchange Rate Fluctuations
Unitd States - Japan

Time Period	Unit Production Cost Difference (%)	SOURCES OF DIFFERENCE (%)							
		Price of Labour	Price of Capital	Price of Materials	Product Mix	Scale Economies	Capacity Utilization	Country Specific Efficiency	Exchange Rate Fluctuation
1977-79	0.6	12.8	-4.6	-8.1	0.0	-4.6	1.2	-0.2	4.3
1979	6.7	12.3	-3.6	-6.3	0.0	-4.2	3.1	1.5	3.9
1980	34.4	15.9	-3.6	-6.3	0.0	-3.5	21.9	2.5	6.3

TABLE 7

Cost Efficiency Differences and Its Sources - United States - Japan

Time Period	Cost Efficiency Difference* (%)	SOURCES OF DIFFERENCE (% Contribution)					
		Product Mix	Scale Economies	Capacity Utilization	Country Specific Efficiency	Interaction	Estimation Residual
1970-72	-21.0	-0.0	37.7	-11.3	62.8	4.5	6.3
1977-79	-2.2	-0.0	213.0	-50.4	-3.9	8.3	-67.0
1979	1.5	0.0	-288.6	190.7	151.9	-32.7	78.6
1980	22.4	0.0	-17.5	83.4	52.4	-25.9	7.5

* $\frac{\text{U.S.}}{\text{Japan}} \times 100$

TABLE 8

Cost Efficiency Differences and Its Sources - United States - Japan

Time Period	Cost Efficiency Difference*+ (%)	SOURCES OF DIFFERENCES (%)			
		Product Mix	Scale Economies	Capacity Utilization	Country Specific Efficiency
1970-72	-19.8	0.0	-8.5	3.3	-15.2
1977-79	-3.6	0.0	-4.6	1.2	-0.2
1979	0.3	0.0	-4.2	3.1	1.5
1980	20.6	0.0	-3.5	21.9	2.5

* $\frac{\text{U.S.}}{\text{Japan}} \times 100$

+ Calculated from the estimated cost function

TABLE 9(a)

Unit Production Cost Difference and Its Sources - United States - Japan
(Equilibrium Not Adjusting for Exchange Rate Fluctuations)

Time Period	Unit Production Cost Difference (%)*	SOURCES OF DIFFERENCES			
		Price of Labour	Price of Capital	Price of Materials	Cost Efficiency Difference
1970-72	7.4	26.1	-6.9	16.7	-21.6
1977-79	-1.9	13.2	-4.0	-5.6	-4.4
1979	2.9	12.4	-2.9	-3.9	-1.8
1980	11.9	15.9	-2.3	-2.5	1.4

* $\frac{U.S.}{Japan}$ X 100

TABLE 9(b)

Unit Production Cost Difference and Its Sources - United States - Japan

(Equilibrium - Adjusting for Exchange Rate Fluctuations)

Time Period	Unit Production Cost Difference (%)*	Sources of Difference			
		Price of Labour	Price of Capital	Price of Materials	Cost Efficiency Difference
1977-79	-5.7	12.5	-4.6	-8.1	-4.4
1979	-0.9	11.7	-3.5	-6.4	-1.8
1980	5.2	14.8	-3.2	-6.5	1.4

* $\frac{U.S.}{Japan} \times 100$

TABLE 10

Cost Efficiency Differences and Its Sources - United States - Japan

(Equilibrium)

Time Period	Cost Efficiency Difference*	SOURCES OF DIFFERENCES		
		Product Mix	Scale Economies	Country Specific Efficiency
1970-72	-21.6	0.0	-8.4	-14.4
1977-79	-4.4	0.0	-4.6	0.2
1979	-1.8	0.0	-4.1	2.3
1980	1.4	0.0	-3.3	4.8

* $\frac{U.S.}{Japan} \times 100$

Table 11

A Comparison of U.S.-Japan Unit Production

Cost Calculations (% Japanese Cost Advantage)[a]

Study	1979	1980
Abernathy, Harbour and Henn (1981)	50.0	
Abernathy, Clark and Kantrow (1983)	[36.6, 43.5][b]	
Federal Trade Commission (1983) - strict weights	-0.3	15.0
Federal Trade Commission (1983) - liberal weights	16.3	34.7
This study (Table 4)	6.7	34.4
This study - equilibrium calculations		
(i) Table 9(a)	2.9	11.9
(ii) Table 9(b)	-0.9	5.2

a $\left(\frac{\text{U.S. Cost}}{\text{Japan Cost}} - 1\right) \times 100\%$

b Based on a mixture of 1979 and 1981 data. The range reflects the fact that no single number can be computed from the data. These numbers are calculated from Table 5.2 of Abernathy, Clark and Kantrow. Transportation costs are excluded from the non-manufacturing costs of Japanese producers.