Japanese exchange rates, export restraints, and auto prices in the 1980s

Regression analysis indicates that, after 1986, Japanese exchange rates had a significant positive effect on prices of U.S. domestically produced automobiles and, hence, that Japanese voluntary export restraints were not binding; pre–1986 results are inconclusive, but consistent with binding voluntary export restraints

Ana Aizcorbe

Changes in Japanese exchange rates affect the prices of U.S.-manufactured light vehicles in two related steps:

1. *The pass-through effect*. A stronger yen increases both the prices of models produced in Japan and the landed cost (the dollar value at the point of importation).
2. *The competing-goods effect*. The increases in landed costs of Japanese models lead to increases in demand and prices of domestic substitutes.

Quotas, such as the voluntary export restraints that were put in place in April 1981, can influence the magnitude of these effects: under binding restraints, where the level of imports reaches the level of the voluntary restraints, cost shocks (such as exchange rate fluctuations) do not affect prices.

Using 1980s price data from the Consumer Price Index (CPI) database, this article applies reduced-form equations to quarterly observations of transaction prices. The resulting estimates of the impact of exchange rates on prices of domestically produced automobiles are an indirect test of whether the voluntary export restraints were binding. Although the results for the early 1980s are inconclusive, results for the late 1980s yield significant exchange rate effects: a 10-percent increase in the yen translates into a 1.2-percent increase in a CPI-like price index for domestically produced automobiles, reflecting both pass-through and competing-goods effects. As one would expect, the elasticities were larger for models that competed more directly with Japanese models. These significant exchange rate effects imply that the voluntary export restraints were not binding over that period.

Ana Aizcorbe is an economist at the Bureau of Economic Analysis, Washington, DC.
E-mail:
Ana. Aizcorbe@bea.gov

Background

During the 1980s, sales of vehicles imported from Japan made up 17 percent to 22 percent of overall sales in the United States. Rising oil prices early in the decade and the resulting increases in demand for more fuel-efficient vehicles gave Japanese automakers an advantage over domestic producers, because Japanese vehicles were smaller and more fuel efficient: the average fuel economy of Japanese cars and trucks sold in the United States was 5 miles per gallon greater than that of American vehicles in the 1980s.[1] Moreover, within the small-car segment, Japanese vehicles tended to be more affordable; during that decade, Japanese automakers enjoyed substantial cost advantages that allowed them to sell comparable vehicles at lower prices.[2]

This intense competition from Japanese brands generated calls for trade protection. An already existing 25-percent tariff on trucks undoubtedly protected that segment. Beginning in 1981, the Japanese agreed to voluntary export restraints on their automobile imports to the U.S. market. Initially, the program allowed just 1.68 million Japanese automobiles into the United States each year. The cap was raised to 1.85 million per year in 1984 and to 2.3 million in 1985, where it remained through the end of the decade. However, the cap applied only to imports from Japan and did not include any sales of automobiles that Japanese firms produced in the United States. Beginning in 1982 with Honda's Marysville plant in Ohio, Japanese automakers began to shift production from Japan to the United States. By 1990, sales of vehicles—autos and light trucks—produced at these so-called transplants accounted for nearly 10 percent of all light-vehicle sales. Taken together, sales of Japanese vehicles produced in Japan and sales of those manufactured in the United States grew over the 1980s and by 1990 made up more than 25 percent of overall sales. (See chart 1.)

The shift to production in the United States also aided Japanese firms when the yen rose in the middle of the decade. From 1985 to 1988, the dollar fell dramatically and closed the period at about half of its original value. (See chart 2.) That undoubtedly raised the landed cost of Japanese imports. During this period, wholesale prices of imported autos increased 25 percent, a marked departure from the preceding 4 years. (See chart 3.) Because sales of imported Japanese automobiles represented about half of the total value of imported automobiles, the sharp rise in import prices would be expected to increase the demand for, and prices of, domestically produced automobiles. However, wholesale prices for domestic autos rose only 7 percent over the period, which was approximately the same as the trend of the previous 4 years.

Framework

An empirical demand framework developed by Jonathan Baker and Timothy Bresnahan provides a vantage point from which to examine the apparent lack of sensitivity of domestic prices to the sharp increase in import prices seen in the late 1980s.[3] The reduced-form approach of these researchers allows for the presence of market power without imposing a particular form of market structure.

On the demand side, there are N demand equations—one for each model—that take the form

$$Q_{nt} = D_n(P_{1t}, P_{2t}, \ldots, P_{Nt}, Y_t), \qquad n = 1,\ldots, N, \tag{1}$$

where Q_{nt} is the number of vehicles of type n (for example, unit sales of the Ford Taurus) that the representative consumer wishes to purchase at time t. The representative consumer's demand depends on the prices of all models (the P_{nt}'s), as well as a number of other factors consolidated here into a single variable (Y_t). Although the factors that shift each demand curve are common to all models, the responsiveness of prices to these factors can vary across models.

On the supply side, consider first the production of domestic models. Suppose the first I of the N models sold in the United States are produced domestically. For these models, pricing behavior is characterized by the supplier relations represented in the following equation:

$$P_{it} = \mathrm{MC}_i(Q_{it}, W_t) + \mathrm{MU}_i(Q_{1t}, Q_{2t},\ldots,Q_{Nt}, Y_t), \quad i = 1,\ldots, I. \tag{2}$$

In this equation, price is equal to marginal cost (MC) plus some markup (MU). Marginal cost for each model i depends on the level of production (Q_{it}) and other factors that shift the cost function (W_t), while the markup depends on the level of production for all other models (all the Q's) and other factors that affect demand (Y_t).

When the voluntary export restraints are not binding, the supply relations for Japanese firms are similar to those of domestically produced models, except that Japanese costs are translated into dollars by the exchange rate (e_t), denominated in dollars per yen. Suppose that $J = I + 1,\ldots,N$ of the models sold in the United States are produced in Japan. Then the supplier relations for Japanese models sold in the United States are written as

$$P_{jt} = \mathrm{MC}_j\,(Q_{jt}, W_t)e_t + \mathrm{MU}_j\,(Q_{1t}, Q_{2t},\ldots,Q_{Nt}, Y_t), \quad j = I + 1,\ldots, N. \tag{3}$$

An appreciation of the yen raises the landed cost and, thus, the price of Japanese models sold in the United States.

Assuming that markets clear, the N supplier relations in (2) and (3) and the N implicit demand equations in (1) can be solved for the $2N$ unknown quantities and prices to yield the following reduced-form equations:

$$\left.\begin{aligned} P_{nt} &= P_n(W_t, Y_t, e_t), \\ Q_{nt} &= Q_n\,(W_t, Y_t, e_t), \end{aligned}\right\} \qquad n = 1,\ldots, N. \tag{4}$$

These equations capture the effect of changes in the exogenous variables (that is, W_t, Y_t, and e_t) on prices and quantities of models when the voluntary export restraints are not binding. In the presence of pass-through and competing-goods effects, increases in the Japanese exchange rate have a positive effect on the prices and quantities of domestic cars. In (4), the effect of exchange rates on the prices and quantities of each model takes all the competitive reactions of other firms into account.

The first-round effects are seen in equations (1) and (3): an increase in the exchange rate increases the price of Japanese models (in (3)), and because Japanese prices affect the quantity demanded of substitutes, demand for domestic models shifts rightward and raises their prices (in (1)). The second-round effects are seen in (2) and (3). Once consumers adjust demand to changes in Japanese prices, firms adjust by altering output and prices ((2) and (3)), and subsequent iterations follow until a new equilibrium is reached.

With binding voluntary export restraints, the supplier relation for Japanese models (equation (3)) becomes a vertical supply curve at $\lambda_j Q_t^{\mathrm{VER}}$, where λ_j is good j's share of the quota, assumed constant over time:

$$Q_{jt} = \lambda_j Q_t^{\mathrm{VER}}, \qquad j = I + 1,\ldots, N. \tag{3a}$$

In these equations, prices for Japanese models are determined solely by the position of the demand curve (1): an increase in the restraint directly lowers the price of Japanese models and indirectly lowers the price of competing models.

The supplier relations in (3a) and (2) and the demand equations in (1) can be solved for the unknown prices and quanti-

Chart 1. Market share for Japanese light vehicles, by location of production, 1980–90

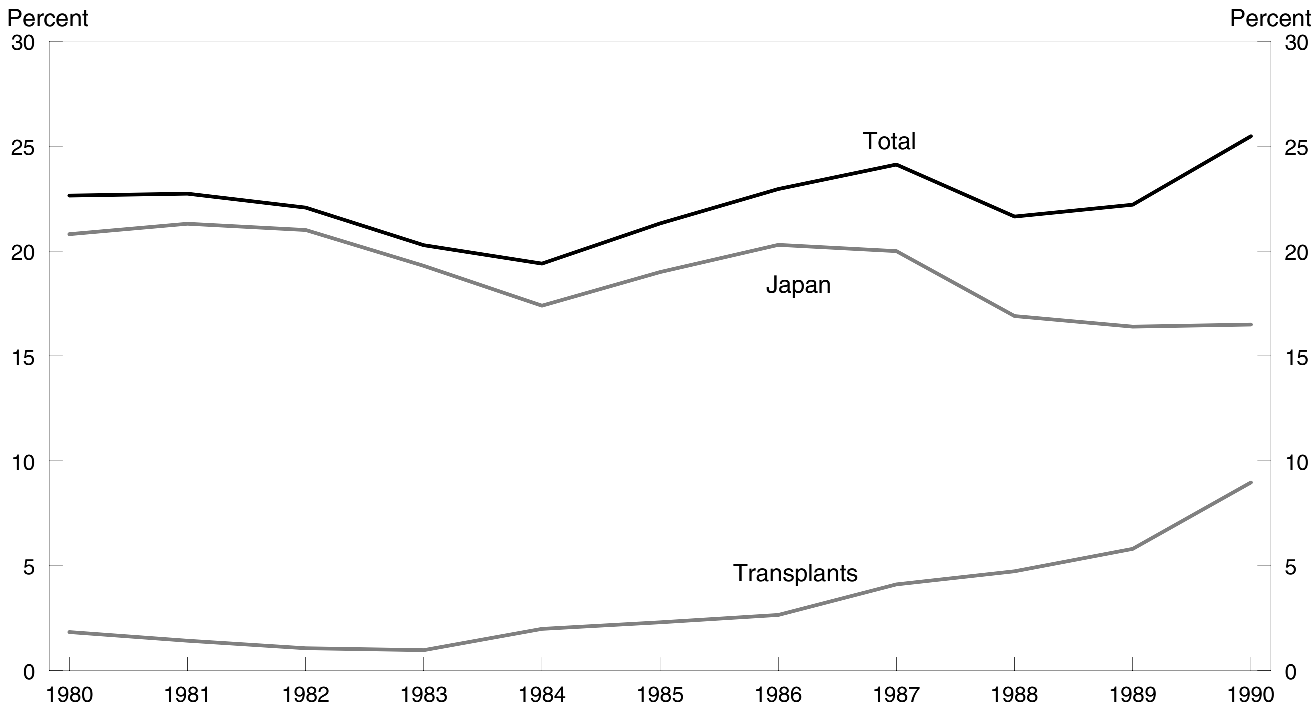


Chart 2. U.S.–Japanese foreign exchange rate, January 1981–July 1993

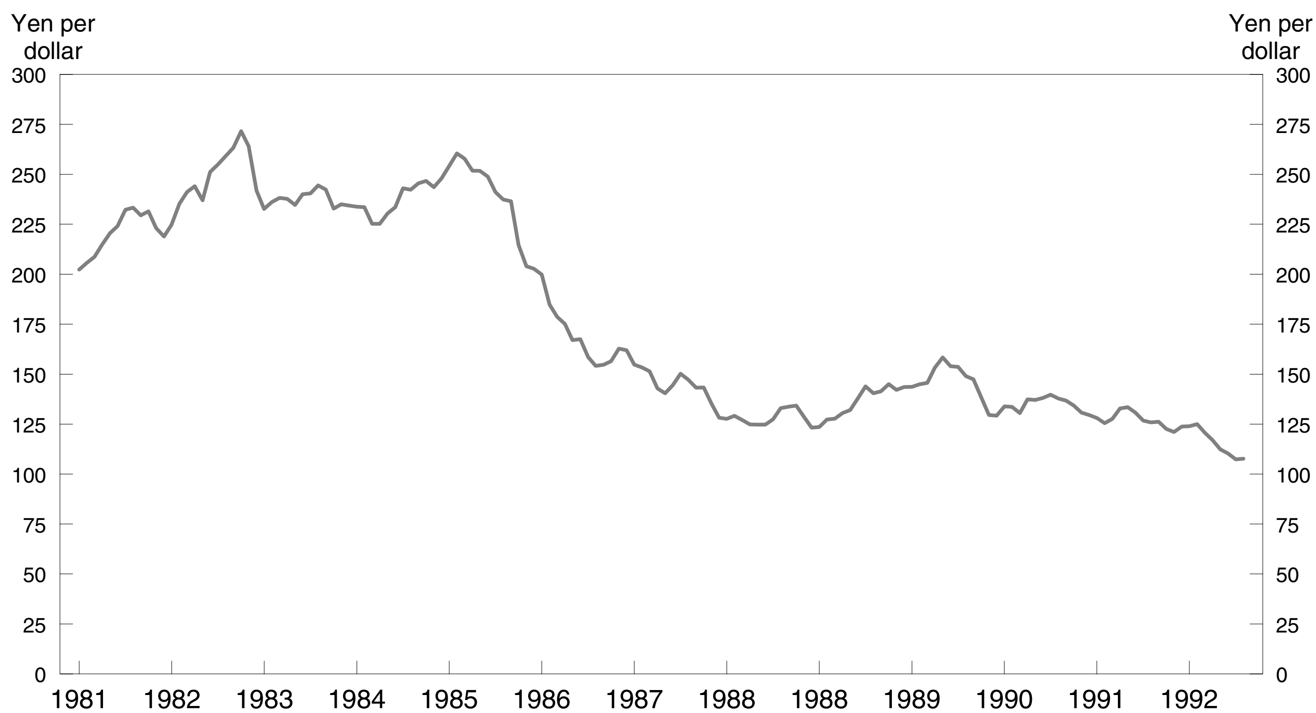
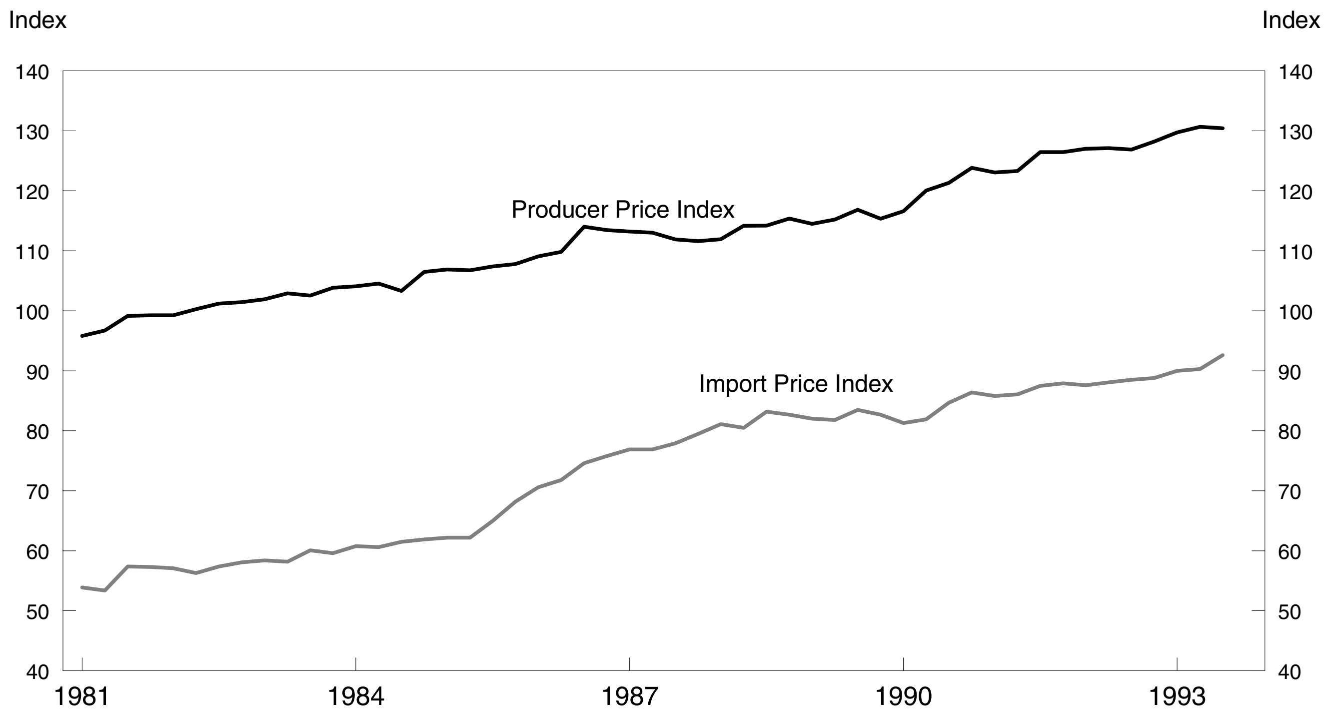


Chart 3. Price indexes for automobiles, second quarter 1981–fourth quarter 1993



ties in terms of aggregate variables to yield the following reduced forms:

$$\left.\begin{aligned} P_{nt} &= P_n(W_t, Y_t, Q_t^{VER}), \\ Q_{nt} &= Q_n\,(W_t, Y_t, Q_t^{VER}), \end{aligned}\right\} \qquad n = 1,\ldots, N. \qquad (5)$$

As before, the parameters can vary across models, so an increase in the voluntary export restraint can have a different effect on, say, a model produced in Japan than it does on a model produced in the United States. Note, however, that, unlike the case in which voluntary export restraints are not binding (equation (4)), here changes in exchange rates have no impact on prices or quantities.

Specification

The possibility of binding voluntary export restraints is accommodated by splitting the sample into two periods—pre-1986 and post-1986—and allowing the trade coefficients to vary across the periods. Specifically, the following I price equations, one for each domestic model, are estimated:

$$\begin{aligned} P_{it} = {} & D_t^{\mathrm{PRE}}[\alpha + \alpha_e(\ln e_t) + \alpha_Q(\ln Q_t^{\mathrm{VER}})] \\ & + D_t^{\mathrm{POST}}[\,\beta + \beta_e(\ln e_t)] \\ & + \gamma_Y(\ln Y_t) + \gamma_W(\ln W_t) + \gamma_X(\ln X_t). \end{aligned} \qquad (6)$$

Here, $D_t^{\mathrm{PRE}} = 1$ over the Japanese fiscal years 1981–85 and zero otherwise, and $D_t^{\mathrm{POST}} = 1$ in fiscal years 1986–91 and zero otherwise. The variable Y_t represents factors in the data set that shift the demand for each domestic model (income and gas prices), W_t represents factors that shift the costs of producing domestic models (automotive wages and steel prices), and X_t represents two time-series variables to capture seasonality (quarterly dummies) and a time trend (one way to account for technological change). Note that Q_t^{VER} is excluded in the post-1986 period: voluntary export restraints were held at 2.3 million cars over that period, making the variable $\ln Q_t^{\mathrm{VER}}$ perfectly correlated with the post-86 dummy intercept (D_t^{POST}). For this period, then, the exchange rate coefficient alone is used to discern whether or not the voluntary export restraints were binding.

Although the equations are estimated at the model level, the voluntary export restraints apply to the total number of autos imported into the United States. It is impossible to know how Japanese authorities parsed out the restraints across firms, let alone models. However, because each equation is estimated separately, the only assumption needed is one about how the restraints for each model changed over time; in that regard, this analysis assumes that each model's quota was proportional to the number of imported cars allowed under the voluntary export restraints. This is clearly a first approximation to a difficult issue.

The regressions were estimated with the use of ordinary least squares. Because the explanatory variables are identical across models, stacking the regressions and running a Zellner technique would not provide any gains in terms of efficiency. Applying Dickey-Fuller tests to the data indicates that the residuals are stationary and the regressions may be estimated in levels (rather than first differences).[4]

Data

The preceding framework is applied to a panel of data on prices for automobiles produced in the United States from 1981 to 1990. The price data are quarterly observations of transaction prices for about 61 models, each used in the CPI to represent a specific size class (for example, economy and standard) produced by a particular division (for example, Pontiac) of a particular domestic firm (for example, General Motors). These data, one of the raw inputs that feed into the calculation of the CPI for cars, were accessed at the Bureau of Labor Statistics.

The aforesaid price data were matched with unit sales data (obtained from *Ward's Automotive Reports*) and the following macro variables:

- the Japanese exchange rate and level for the voluntary export restraints (obtained from the Japan Auto Manufacturers Association)
- real personal disposable income (from the Bureau of Economic Analysis),
- hourly earnings for workers in the motor vehicles and motor vehicle equipment industry (SIC 371), and
- the PPI's for gasoline and steel (both from the Bureau of Labor Statistics).

Results

For domestic models that substitute with Japanese models, a binding voluntary export restraint implies a zero exchange rate coefficient and a negative coefficient of the voluntary export restraint (as in equation (5)), whereas a nonbinding voluntary export restraint implies a positive exchange rate coefficient and a zero coefficient of the voluntary export restraint (as in equation (4)). Alternatively, models that are not viewed as substitutes for Japanese models would show zero coefficients for all trade variables.

The following two tabulations, the first for exchange rate elasticities and the second for the level of voluntary export restraints, show the estimates of the coefficients for the pre-1986 period:

Exchange rate elasticities:

	Statistical significance		
Sign	*Significant*	*Insignificant*	*Total*
Total	8	53	61
Positive	4	32	36
Negative	4	21	25

Level of voluntary export restraints:

	Statistical significance		
Sign	*Significant*	*Insignificant*	*Total*
Total	9	52	61
Positive	2	14	16
Negative	7	38	45

The results for this period are inconclusive. On the one hand, the fact that most of the coefficients, both of the exchange rate and of the voluntary export restraints, are not significantly different from zero is consistent with the view that domestic models were not credible substitutes for Japanese models and also is consistent with previous findings that domestic prices were not affected by potentially binding restraints.[5] On the other hand, though statistically insignificant, the signs on the coefficients of the voluntary export restraints are largely negative and, thus, consistent with the binding restraint scenario propounded separately by Robert Feenstra and Pinelopi Goldberg.[6]

The following tabulation shows exchange rate estimates for the post-1986 period:

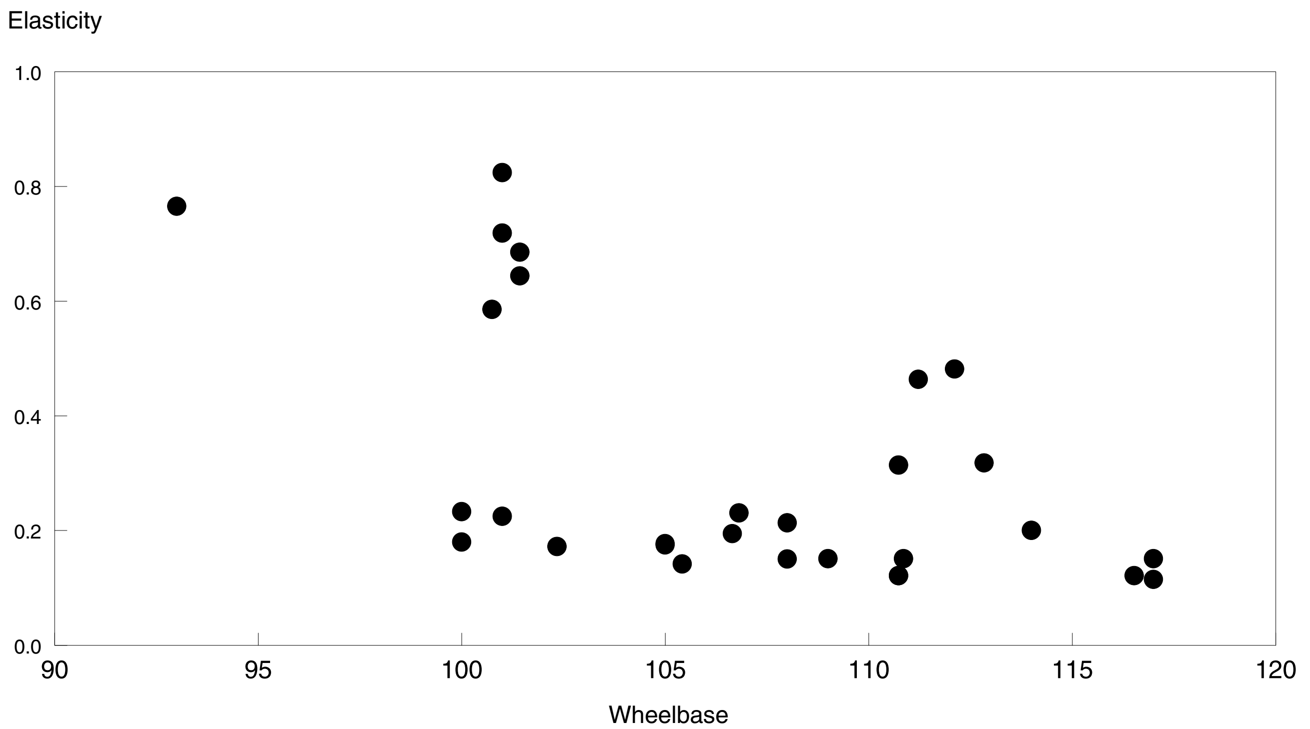
	Statistical significance		
Sign	*Significant*	*Insignificant*	*Total*
Total	31	30	61
Positive	27	16	43
Negative	4	14	18

The estimates show significant positive exchange rate effects and, hence, reject the possibility of binding voluntary export restraints: 43 of 61 exchange rate coefficients are greater than zero, and only 4 of the negative coefficients are statistically significant. This finding is consistent with that reported by Goldberg, who used similar data (transaction prices).[7]

Among the 27 models that show statistically significant positive elasticities, the estimated elasticities are larger for small models that substituted more closely with Japanese models. Chart 4 plots the models' elasticities against their wheelbase—the width of the models, a proxy for the size of the vehicle—and shows that the estimated elasticities tend to be smaller as the size of the model increases.

Thus, one reason that aggregate price measures such as the CPI showed little change in response to increases in import prices may be related to the fact that most domestic sales were for (larger) models that did not substitute directly with Japanese models. To measure the strength of this possibility, an average elasticity was constructed on the basis of the estimated parameters for those models which were statistically significant and an estimate of zero for those which did not show statistically significant results. The resulting elasticity was 12.4 percent, indicating that a 10-percent increase in the yen over the late 1980s would have increased the *average* price of Big Three vehicles only by about 1.2 percent. □

Chart 4. Statistically significant exchange rate elasticities, post-1986 period



Notes

ACKNOWLEDGMENT: This work was completed at the Bureau of Labor Statistics while I was employed at the Federal Reserve Board. The views expressed here are solely mine and do not necessarily reflect those of staff at the Bureau of Economic Analysis or the Bureau of Labor Statistics. I thank Kevin Daly, colleagues at the Federal Reserve, and participants in the NBER Productivity Workshop for valuable comments and David Martin for research assisance. Special thanks go to Ronald Johnson of the Bureau of Labor Statistics for a meticulous read of the manuscript and for pointing out several important qualifications to the assumptions and results.

[1] *Transportation Energy Databook* (Oak Ridge, TN, Oak Ridge National Laboratory, October 2006); on the Internet at **www.cta.ornl.gov/data/download25.shtml**.

[2] Ana Aizcorbe, Anne Friedlander, and Clifford Winston, "Cost Competitiveness of the U.S. Automobile Industry," in Clifford Winston and associates, *Blind Intersection? Policy and the Automobile Industry* (Washington, DC, Brookings Institution, 1987).

[3] Jonathan B. Baker and Timothy F. Bresnahan, "Estimating the Residual Demand Curve Facing a Single Firm," *International Journal of Industrial Organization*, vol. 6, no. 3 (1988), pp. 283–300.

[4] See William H. Greene, *Econometric Analysis* (Upper Saddle River, NJ, Prentice Hall, 2003) for a description of Zellner regressions and Dickey-Fuller tests. Regression results are available from the author upon request.

[5] Steven Berry, James Levinsohn, and Ariel Pakes, "Voluntary Export Restraints on Automobiles: Evaluating a Trade Policy," *American Economic Review*, June 1999, pp. 400–30.

[6] Robert C. Feenstra, "Quality Change Under Trade Restraints in Japanese Autos," *Quarterly Journal of Economics*, February 1988, pp. 131–46; Pinelopi Koujianou Goldberg, "Trade Policies in the U.S. Automobile Industry," *Japan and the World Economy*, June 1994, pp. 175–208.

[7] Goldberg, "Trade Policies."