International Journal of Industrial Organization
17 (1999) 299–318

Recovering from a bad reputation: changing beliefs about the quality of U.S. autos

Mark W. Nichols[a], Gary M. Fournier[b,*]

[a] *Department of Economics/030, College of Business Administration, University of Nevada, Reno, NA 89557-0016, USA*

[b] *Department of Economics, Florida State University, Tallahassee, FL 32306-2180, USA*

Received 29 March 1995; accepted 15 April 1998

Abstract

Acquiring a reputation for high quality is especially urgent for producers in markets for durable goods with quality characteristics that remain uncertain over the product's life. Using data from the U.S. automobile industry, our empirical evidence shows that a poor reputation associated with U.S. autos during the early 1980's has persisted in reducing prices of more recent models, despite quality improvements. As of 1990, used cars in the U.S. were still discounted five percent on average relative to their Japanese counterparts. However, models with the strongest improvement in reported vehicle quality have bridged the gap somewhat in resale value.

Keywords: Reputation; Durable goods; Automobiles; Quality improvements

JEL classification: D83; L62

1. Introduction

The process whereby a firm acquires a reputation for high quality in durable goods is recognized in the theoretical literature of industrial economics (e.g., Shapiro, 1983; Klein and Leffler, 1981). At the same time, empirical evidence about reputation is limited. In recent years, U.S. manufacturers of consumer durables have attempted to improve their reputation for quality. For example, as a

* Corresponding author. Tel.: +850-644-7080; Fax: +850-644-4535; E-mail: gfournie@coss.fsu.edu

PII: S0167-7187(98)00022-8

consequence of increased competition from the Japanese automobile industry over the past decade, the Big Three (GM, Ford, and Chrysler) have taken steps to improve quality and reduce costs. Early evidence indicates that this strategy has been successful, and the quality/cost gap between the Big Three and the Japanese is substantially narrowing (e.g., Kwoka, 1991, and Klein, 1993).

Despite these gains, the U.S. car-buying public appears reluctant to embrace the news of improved quality. Automobiles by their nature prevent easy determination of quality. Aspects of quality like maintenance costs, durability, and safety in handling are established only by observing over time the performance of a large sample of cars in operation. How new information is assimilated with prevailing beliefs about quality ultimately determines the firm's success in overcoming a poor reputation.

Transforming an established firm from its low-quality reputation to one with recognized higher quality raises a number of interesting economic issues. How quickly do agents in the market for used cars proceed to update their beliefs? Do low-quality reputations persist in lowering market prices of new, improved models? Finally, can it be shown empirically that signs of reputational updating are strongest when objective reports of quality reveal substantial gains? Simply put, are price adjustments stronger for models introducing large quality improvements compared to those with quality relatively unchanged?

This paper presents an empirical analysis of time series data on used-car prices and indicators of quality. We distinguish quality variables based on both past and current indicators. To the extent that these variables proxy actual beliefs of traders in the market, we find supporting evidence of lingering reputational effects on prices associated with low-quality cars produced from the early 1980's, as distinct from the favorable effects attributable to quality improvements in newer vintage U.S. cars.

Section 2 describes the changes in quality occurring in the U.S. automobile industry over the past decade and a half, providing a backdrop for the empirical analysis. The specification of the user-cost model of car depreciation, in Section 3, extends earlier work by Emmons and von Hagen (1991). Details of the price and quality index data and empirical results follow in Section 4 and Section 5. This evidence is reinforced by further tests, provided in Section 6, based on separate data on the relative depreciation of ''twin'' cars that are marketed alternately with U.S. and Japanese trademarks. Conclusions and implications are elaborated in the final section.

2. Quality changes in U.S. Autos

As late as 1978, the Big Three accounted for 81% of the 11 million vehicles sold domestically in that year. General Motors (GM) alone accounted for 45% of the total market, had sales of $63 billion, and profits of $3.5 billion. By 1991, the Big Three's share had fallen to only 63% of the 8 million vehicles sold. This reduction in the competitiveness of domestic cars is widely blamed on a large deterioration in their quality relative to the Japanese imports.

In 1980, the Big Three averaged 740 defects per 100 vehicles assembled, whereas Japanese imports averaged 205. The cost to Chrysler of such defects was $274 per car (see Kwoka, 1991). By 1989, however, substantial effort to revive production techniques, labor relations, and parts procurement had been made. The result was a 78% reduction in the number of defects, to 161 per 100 vehicles. The Japanese also made quality improvements over this period with the number of defects falling 42%, to 119 per 100 vehicles. In 1993, the gap continued to narrow with 119 and 94 defects per 100 for the Big Three and the Japanese respectively.

The end result of the new competition, cost reductions, and incorporation of Japanese management techniques into domestic production was a substantial improvement in quality relative to the beginning of the 1980's. There is a growing consensus that the gap between domestic and Asian models has narrowed considerably. Furthermore, many predict this to narrow further over the next decade (e.g., Spencer, 1992 and Klein, 1993).

In the current study, ratings of used automobiles given by *Consumer Reports* (CR) are used as a measure of the subjective beliefs traders hold about car quality.[1] These rankings are summaries of consumer surveys sent by Consumers Union to its subscribers and reflect actual experience from vehicle ownership. Automobiles are ranked and graded on 17 trouble spots such as engine, cooling system, electrical system, transmission, exhaust system, body rust, etc. Averaging over all considered trouble spots, an overall ranking is computed relative to the average experience of all models of the same model year, adjusted for mileage. Vehicles are placed in one of five categories: much worse than average, worse than average, average, better than average, and much better than average. In order to receive a better or worse than average rating for a specific trouble, the model's complaint rate differed by at least 2.5 percentage points from the average complaint rate. To earn a much better or much worse rating the complaint rate had to differ by at least 5 percentage points. We assign a grade of 5 for a vehicle rated as much worse than average, 4 for worse than average, 3 average, 2 better than average, and 1 much better than average.

For our purposes, it is assumed that consumers hold prior beliefs about quality that are derived from all trouble indices available for the previous five years.[2] That

[1] *Consumer Reports* was chosen because Consumer's Union, unlike other sources of published quality data, accepts no advertising and does not rely on the automobile industry for its revenues. In addition, CR is widely available and is a low-cost information source. Finally, CR is one of the few sources from which model-specific information on the quality of used automobiles can be obtained over time on a consistent basis.

[2] The choice of five years is necessary because the models are only tracked for up to seven years. While we have chosen to fix the reputation proxy as the average value of the lagged five years, it would be better to examine the issue with longer longitudinal data than are available to us.

is, the historic trouble index at time t for a given model produced in year v, $R_{t,v}$, $\{t=1, 2,...,5; v=1985,...,1990\}$, is the reputation attributed to a model and is the average of all trouble indices for identical models produced in earlier years. By way of illustration, consider Table 1 below that gives the trouble index ratings and historical trouble index for the 1983 through 1989 Buick Century. Columns represent model year (v) and rows represent purchase or calendar year (t). In 1989, for example, the 1988 Century was rated average (trouble index of 3). The historical trouble index for the 1988 Century in 1989, $\boldsymbol{R}_{1,1988}$, is the average of *all* numbers for the 1983 through 1987 models, including what they received in earlier years as well as 1989. This yields a value of $\boldsymbol{R}_{1,1988}=4.65$. In 1990, the 1988 Century is two years old and receives a rating of 4. The historic trouble index, $\boldsymbol{R}_{2,1988}$, is now the average of all numbers for the 1983 through 1987 models (earlier years and the ratings they receive in 1990) plus the rating of 3 the 1988 model received when it was one year old. This yields a value of $\boldsymbol{R}_{2,1988}=4.60$.

To capture the effect of new information arriving at time t, a current trouble index variable, $\boldsymbol{Q}_{t,v}$, is defined as the trouble index reported at time t minus $\boldsymbol{R}_{t,v}$. For the 1988 Century, $\boldsymbol{Q}_{1,1988}$ equals -1.65 $(3-4.65)$. Similarly, $\boldsymbol{Q}_{2,1988}$ equals $-0.\ 60$ $(4-4.60)$. This measure reflects the magnitude of difference between the current model's quality rating and the historic rating, or reputation, that prevailed before the current report arrived. $\boldsymbol{Q}_{t,v}$ thus differentiates between favorable news,

Table 1
(a) Consumer Reports Rating for the Buick Century

	Model Year (v)						
Purchase year (t)	1983	1984	1985	1986	1987	1988	1989
1984	3						
1985	4	4					
1986	5	5	4				
1987	5	5	5	5			
1988	5	5	5	5	4		
1989	5	5	5	5	4	3	
1990		5	5	5	4	4	3
1991			5	4	4	4	3
(b) Historic Trouble Index, ***R***, for the Buick Century							
1984	n.a.						
1985	n.a.	n.a.					
1986	n.a.	n.a.	3.88				
1987	n.a.	n.a.	4.04	4.47			
1988	n.a.	n.a.	4.19	4.58	4.75		
1989		n.a.	4.25	4.64	4.76	4.65	
1990			4.28	4.68	4.76	4.60	4.60
1991				4.70	4.72	4.55	4.48

n.a. implies that model year is not in our data set.

indicating the quality rating has improved, and unfavorable reports showing the newest ratings to be worse than before.

It must be acknowledged that these data provide an imperfect measure of quality. Because the average quality of cars has improved over time and ratings by Consumer Reports are relative to the average car in each year, our measure of the current trouble index, $\boldsymbol{Q}_{t,v}$, understates the absolute level of improvement. For example, the 1988 Ford Thunderbird's 1990 rating is equal to its prior. Consequently, the value of $\boldsymbol{Q}_{t,v}$ is zero for that year, despite the fact that this vehicle is a higher quality one than its predecessors. Nevertheless, as discussed further below, we corroborate the overall reliability of this measure with an alternative analysis of cars produced under U.S.—Japanese joint venture. In addition, rather than solely relying on separate historic and current trouble indices, the impact of time-varying quality reports on reputation is modeled with a Koyck transformation, allowing for a gradual decay in the influence of previous information/reputation on the relative capital loss.

The period 1985 to 1990 was one of substantial improvement in quality, especially for U.S. automobiles. As a result of how the quality indices are constructed, approximately 50% of the vehicles show an improvement in quality over the whole period. To illustrate the relative changes by country of origin, let the reputational change over the period 1985–90 be defined as $R_{t+1,v} - R_{1,v}$, where $R_{1,v}$ is the initial historic trouble index (e.g., the reputation that would be attributed to a 1985 model in 1986) and $R_{t+1,v}$ is the final historic trouble index (e.g., the reputation that would be attributed to a 1985 model in 1991). While U.S. automobiles account for 66% of the observations in the sample, they account for 76% of the automobiles showing an improvement in quality, $R_{t+1,v} - R_{1,v} < 0$.

These relative improvements lend credence to the statements made in the trade press about improvements in quality made by U.S. manufacturers. Again, if a model's changing reputation generates price effects in the market, we will expect to see the greatest impact on the subset of vehicles with the most dramatic changes. The changes in quality discussed above make the U.S. automobile market a prime candidate for studying the presence of reputation and its effect on prices.

3. The empirical model

To test the effects of reputation, we employ a user-cost model similar to Emmons and von Hagen (1991). The user cost approach, as applied by Emmons and von Hagen (EV) to the German automobile market, suggests that the prices of durable goods like automobiles depend on their expected future service flows and maintenance costs.

In the EV model, equilibrium prices at any time t are determined by the condition that the expected cost of owning a car for a given holding period is just equal to the implicit rental price of its services, including maintenance costs plus any capital loss incurred over the holding period.[3] Given an implicit rental rate, γ_t, equilibrium requires

$$\gamma_t = P_t - \delta E(P_{t+1}) + \delta E(C_t) \tag{1}$$

where P_t is the current price, $E(P_{t+1})$ the expected price in one year, $E(C_t)$ the expected maintenance costs, and δ is the discount factor. EV further assume that implicit rental rates are related through an economic depreciation factor, $\psi_t \in [0, 1]$,

$$\gamma_t = \psi_t^* \gamma_{t-1} \tag{2}$$

Eq. (2) states that a one-year old car's implicit rental rate is some fraction of its new car rate.[4]

There are two expectation terms required for modeling Eq. (1) above. Consider first the expected future price. If consumers do not expect systematic shifts in relative prices over the holding period (i.e. market conditions are stable) they can rationally base their expectations by looking at the relative value of cars one-year older than one they consider purchasing. Therefore,

$$E(P_{t+1,v}) = P_{t,v-1} + \epsilon_t \tag{3}$$

where $E(P_{t+1,v})$ is the expected price of the current vehicle one year in the future, $P_{t,v-1}$ is the current price of the same type one year older, and $\epsilon_t \sim N(0, \sigma^2)$, $t = 1, 2, 3, \ldots T-1$. More generally, the expected future price might be determined by a vector of macro variables, M_t, including interest rates and other economic indicators, provided that the conditional expectation of future price is unbiased given all available information in each period, i.e.

$$E(P_{t+1,v} | M_t, P_{t,v-1}) = P_{t+1,v} + \epsilon_t \tag{4}$$

Second, to account for the expected maintenance costs, EV assume costs are linear in both a quality effect and make or brand effect. A dummy variable, $\boldsymbol{D}$, equals one if a car is of a given make (e.g. Chevrolet), zero otherwise. Furthermore, they employ as a quality index, $Q_{t,v-1}$, representing the fraction of automobiles of a given model that are one year older needing serious repair. Under stable market conditions, EV predict that expected maintenance costs should be rationally based on the trouble index for the same model of car that is one year

[3] EV adopt a two-year holding period, in part because of the two-year interval between vehicle inspection periods for their data from Germany. For the data in this study, in contrast, a one-year holding period was chosen. To avoid confusion, we are using a one-year holding period throughout the discussion.

[4] A potential source of specification error is introduced by this assumption since implicit rental rates may not change at a constant rate. While this assumption may not hold true, there is some evidence for it, and indeed it has long been used in the literature on automobile demand. See, e.g., Wykoff (1973).

older. The linearized cost function in EV is expressed in the following general form

$$\mathrm{E}(C_{t,v}) = \gamma_o + \beta_1 Q_{t,v-1} + \sum \beta_i D_i + \eta_t \tag{5}$$

where this function captures the informational effects of $Q_{t,v-1}$, the current observed quality of a one-year older car of the same model,[5] and allows for additional 'fixed effects' associated with each car maker.

The current study generalizes this approach to accommodate time periods of changing beliefs. While the approach taken in this study is similar to EV, it is able to identify dynamic changes in reputation in data covering a period of well-documented innovation in the U.S. auto industry, 1985–1990. Suppose it were true that the Big Three have been making significant quality improvements gradually over a period of years. If consumers believed this were happening, they would discount past information heavily and rely more on contemporaneous information. Alternatively, if prior information is significant in explaining depreciation profiles, it would suggest that even when contemporaneous news is favorable, consumers do not believe it fully.

To test these effects, the model incorporates measures relating both to prior beliefs about quality as well as updated quality information from public reports. Recall that $\boldsymbol{R}_{t,v}$ and $\boldsymbol{Q}_{t,v}$ are the period t historic and current trouble indices for a car of vintage v, respectively. Thus, Eq. (5) is replaced by a more general function containing measures of both prior and contemporaneous information.

$$r_{t,v} = \mathrm{E}^r(C_{t,v}) = \gamma_o + \beta_r R_{t,v} + \beta_q Q_{t,v} + \sum \beta_i D_i + \eta_t \tag{6}$$

Suppressing the subscript for vintage, substituting (6) into (1) yields

$$P_t - \delta P_{t+1} = \gamma_t - \delta \gamma_o r_t + \xi_t \tag{7}$$

where $\xi_t = \delta(\epsilon_t + \eta_t)$.This can be further simplified to

$$P_t - \delta P_{t+1} = \gamma_t(1 - \delta \pi_t r_t) + e_t \tag{8}$$

where $\pi_0 = 1$, $\pi_t = \pi_{t-1}\psi_t^{-1}$, $e_t = \xi_t/\gamma_t$, and $t = 1, 2, 3,...T$.

One can update Eq. (8) by one holding period and take the ratio yielding

$$\frac{P_t - \delta P_{t+1}}{P_{t+1} - \delta P_{t+2}} = \frac{1 - \delta \pi_t r_t \ + e_t}{\psi_{t+1}[1 - \delta \pi_{t+1} r_{t+1}] \ + e_{t+1}} \tag{9}$$

This transformation removes the model-specific economic depreciation factor,

[5] The reader is cautioned that we are retaining the notation $\boldsymbol{Q}$ somewhat loosely to represent the proxy variable for contemporaneous quality, although in the EV study it is measured quite differently than we have done with *Consumer Reports* data.

leaving only variables in the equation that are directly observable. Moreover, it cancels out time-invariant characteristics, justifying an empirical cross-section analysis of automobiles without the need for a detailed hedonic model of price determination. To apply OLS, we take the log of (9), a linear approximation on the right hand side, and use the linearity of the expected cost function to get[6]

$$\begin{aligned}\ln(P_t - \delta P_{t+1}) - \ln(P_{t+1} - \delta P_{t+2}) &= k_1 + k_2 R_{t,v} + k_3 Q_{t,v} \\ &+ k_4 R_{t+1,v} + k_5 Q_{t+1,v} + \sum \beta_i X_i + e\end{aligned} \tag{10}$$

The dependent variable is the relative (expected) capital loss, ***RCL***, and it reflects the change in the expected capital loss associated with holding a vehicle for one year. The coefficients k_2 and k_4 show reputational effects, whereas k_3 and k_5 reflect adjustments to new quality reports. Automobiles with higher values of $\boldsymbol{R}_{t,v}$, i.e. those with a relatively poorer reputation, will have a lower price $\boldsymbol{P}_t$. Thus, we expect $k_2<0$ and $k_4>0$, since poor reputations lower agent's reservation prices. Similarly, favorable news arriving should partially mitigate the effects of a poor reputation. Since $Q<0$ represents an improvement in quality, a priori we expect $k_3<0$ and $k_5>0$.[7] Finally, the vector $\boldsymbol{X}$ in the equation includes fixed-effects variables controlling for car maker, model year, age, and the small car segment.[8]

It is useful to consider further an alternative information structure than the one presented above.[9] Rather than separate into historic and current trouble indices, the impact of time-varying quality reports on reputation might be modeled with a Koyck distributed lag, allowing for a gradual decay in the influence of previous information/reputation on the relative capital loss. In place of $\boldsymbol{R}_{t,v}$ and $\boldsymbol{Q}_{t,v}$, the Koyck (distributed lag) reputation variable $\boldsymbol{KR}_{t,v}$ would be defined as

$$KR_{t,v} = \sum Q_{t,v} \lambda^{t-v} \tag{11}$$

[6] When taking logs on the right hand side of (9) we use a linear approximation, noting that $\ln(1+x) \simeq x$.

[7] Alternatively, the equilibrium relationship in Eq. (1) implies that two vehicles (j and j′) that are otherwise identical or perfect substitutes must have identical rental prices. If the function incorporating all reputation and other quality information for vehicle type j obtains a more favorable rating than for j′, then it must be that $P_t > P'_t$. That is, vehicles of type j′ must incur lower expected capital losses to compensate buyers for the higher expected maintenance costs. In Eq. (10), this implies $k_2<0$, $k_4>0$, $k_3<0$ and $k_5>0$.

[8] Since automobile prices are influenced by macro factors we also ran regressions controlling for the interest rate and the price of gasoline at time *t*. These variables were collinear with age, however, since both vary year to year. Replacing age with the interest rate and price of gasoline does not change our inferences about the informational variables, nor our overall conclusions. While both variables were significant, we prefer the specification with model year and age dummies since it broadly captures any fixed factors which are specific to time *t*.

[9] The authors thank an anonymous referee for suggesting this approach.

This model changes the expected cost Eq. (6) and the estimating Eq. (10) to (6′) and (10′) respectively.

$$r_{t,v} = E^r(C_{t,v}) = \gamma_o + \beta_{qr} KR_{t,v} + \sum \beta_i D_i + \eta_t \tag{6′}$$

$$\ln(P_t - \delta P_{t+1}) - \ln(P_{t+1} - \delta P_{t+2}) = k_1 + k_2 KR_{t,v} + k_3 KR_{t+1,v} + \sum \beta_i X_i + e \tag{10′}$$

4. Data description

The sample data underlying Table 2 are panel data consisting of 120 models of 30 makes of automobiles. For each of the six model years from 1985 to 1990, there are observations on more than 100 types of vehicles. In some instances, a particular make and model is observed across all model years (e.g. the 1985 through 1990 Cadillac Seville). In other instances, vehicles are discontinued or introduced for the first time. The criterion for selection into the sample was the existence of a persistent and reliable data series (both quality and price) across the life of the vehicle.[10]

Vehicles are further identified by age, where AGE(1) represents a one-year old vehicle.[11] This yields a total of 675 observations on price and quality for one, two and three year old vehicles. The sample becomes truncated past AGE(3) since the reporting format for the price data changed after 1993.[12] Consequently, 565 observations exist for a four-year old automobile (1985–1989 models), 458 for a five-year old vehicle (1985–1988 models), etc. The reason for distinguishing vehicles by age is that reputation is expected to play a predominant role in the early stages of a vehicle's lifetime depreciation profile when little is known about the current model. Over time, its effect will diminish, yielding to the arrival of new information about the performance of the model that accumulates with experience.

[10] The sample includes types which existed for any part of the n model years, 1985 through 1990. Thus, while the Ford Taurus was not introduced until 1986, and is still produced today, and the Chevrolet Nova began production (again) in 1985 but was discontinued after 1988, both vehicles are contained in the sample due to the reliability and availability of the data. On the other hand, an example of a vehicle that was not included is the Cadillac Cimarron. While the Cimarron was produced from 1982–1988, reports on its quality were sporadic throughout the sample period.

[11] New vehicles are not examined here for two reasons. First, novelty effects may distort new car prices, distorting the relationship between reputation and the relative capital loss or depreciation. Second, the new car prices in our sample are the manufacturer's suggested retail price, and do not reflect the actual new price which may differ due to incentive packages and dealer discounts.

[12] Edmund's Used Car Price guide changed its format after 1993, changing the base model that prices are reported on at the same time. As a result, price data after 1993 are not compatible with earlier price data.

Table 2
Variable definitions and descriptive statistics

Name	Description	Mean (St. Dev)
Relative Capital Loss	Log change in the one-year holding costs, i.e. $\ln(P_t - \delta P_{t+1}) - \ln(P_{t+1} - \delta P_{t+2})$.	0.2664 (0.4179)
Historic Trouble Index ($\boldsymbol{R}_{t,v}$)	At time t, for a car made in year v, average trouble index for five previous model years, incorporating all information up to time $t-1$.	3.1230 (1.2701)
Historic Trouble Index ($\boldsymbol{R}_{t+1,v}$)	At time $t+1$, for a car made in year v, average trouble index for five previous model years, incorporating all information up to time t.	3.1015 (1.2254)
Current Trouble Index ($\boldsymbol{Q}_{t,v}$)	Trouble index at time t for a car made in year v minus the historic trouble index $\boldsymbol{R}_{t,v}$.	−0.0769 (0.7255)
Current Trouble Index ($\boldsymbol{Q}_{t+1,v}$)	Trouble index at time $t+1$ for a car made in year v minus the historic trouble index $\boldsymbol{R}_{t+1,v}$.	−0.0725 (0.6741)
Model Year (1985)	Dummy variable equal to 1 if model is produced in year 1985.	0.2175 (0.4127)
Model Year (1986)	Dummy variable equal to 1 if model is produced in year 1986.	0.2581 (0.4377)
Model Year (1987)	Dummy variable equal to 1 if model is produced in year 1987.	0.2200 (0.4144)
Model Year (1988)	Dummy variable equal to 1 if model is produced in year 1988.	0.1605 (0.3671)
Model Year (1989)	Dummy variable equal to 1 if model is produced in year 1989.	0.0995 (0.2994)
Model Year (1990)	Dummy variable equal to 1 if model is produced in year 1990.	0.0444 (0.2060)
GM	Dummy variable equal to 1 if model is a General Motors product.	0.3317 (0.4709)
Ford	Dummy variable equal to 1 if model is a Ford product.	0.1478 (0.3549)
Chrysler	Dummy variable equal to 1 if model is a Chrysler product.	0.1844 (0.3879)
Japanese	Dummy variable equal to 1 if model is a Japanese product.	0.1254 (0.3312)
Other	Dummy variable equal to 1 if model is European or not in one of above categories.	0.2107 (0.4079)
Age (1)	Dummy variable equal to 1 if model is one year old.	0.2951 (0.4562)
Age (2)	Dummy variable equal to 1 if model is two years old.	0.2542 (0.4355)
Age (3)	Dummy variable equal to 1 if model is three years old.	0.2039 (0.4030)
Age (4)	Dummy variable equal to 1 if model is four years old.	0.1507 (0.3579)
Age (5)	Dummy variable equal to 1 if model is five years old.	0.0961 (0.2948)
Small	Dummy variable equal to 1 if model is classified as small by *Consumer Reports*.	0.1737 (0.3789)

A description of variables is given in Table 2. All prices are third quarter national retail averages taken from Edmund's Publications (1985–1993) and are in 1986 dollars, deflated for inflation using the Consumer Price Index. The discount factor is $\delta=(1+i)^{-1}$, where i is the one-year Treasury Bill rate, corrected as well for the rate of inflation.

5. Results

Table 3 and Table 4 provide results from estimating Eq. (10). We report alternative results to recognize that the quality measures offered by *Consumer Reports* are imperfect and there is likely to be some degree of measurement error. Along with ordinary least squares (OLS) estimation of the models, instrumental variables (IV) estimates are reported. Following Durbin's rank method, as described in Greene (1997) and Fomby et al. (1984), our IV approach uses ordinal information contained in the observed quality variables and, for each one, constructs the instrumental variable as the value of its rank ordering, $i=1,...,n$.[13] As one can see, the results are quite robust between the two alternative estimators.[14]

As a check of the robustness of our historic and current trouble indices we also provide results from estimating a more flexible distributed lag model. In particular, the results from estimating the Koyck lag model given by Eq. (10′) are also reported in Table 3. The close qualitative consistency of the OLS, IV, and Koyck estimates provides some reassurance that our historic and current trouble indices capture, to some degree, the adaptive reputational information in this market.

In columns one and two of Table 3, the basic model supports our conjecture that reputation plays an important role in the determination of expected quality and price in the U.S. market for used automobiles. The results indicate that both previous and current indicators of quality have a significant role in the determination of the relative capital loss (***RCL***). All four informational variables are significant and of the expected sign. The significance of the historic trouble index, $\boldsymbol{R}_{t,v}$, suggests the market is slow to dismiss prior expectations about quality. Automobiles with poor reputations, i.e. relatively large values of $\boldsymbol{R}_{t,v}$, have

[13] Durbin's IV procedure requires in this case that the ranking of the historic and current indices always be the same as the ranking of the unobserved, true quality variable. It provides consistent estimates of the parameter estimates when there are errors in variables so long as the ranking of the independent variable is not determined by the size of the measurement error. It may be possible that our measurement errors are large enough to invalidate this approach, but we are unable to examine this possibility with the data.

[14] This is confirmed by a variant of the Hausman test under the null hypothesis of no contemporaneous correlation between the errors and the regressors (Kennedy, 1992, p. 148). The F statistic for this test is 0.2881, which fails to reject the null given the critical value of $F(4, 2007)=2.37$.

Table 3
OLS and instrumental variables estimation of reputation model

Independent variable	Reputation		No reputation		KOYCK	
	(OLS)	(IV)	(OLS)	(IV)	(OLS)	(IV)
Historic Trouble Index	0.150**	−0.151**				
($\boldsymbol{R}_{t,v}$)	(2.40)	(2.09)				
Historic Trouble Index	0.171***	0.173***				
($\boldsymbol{R}_{t+1,v}$)	(2.72)	(2.39)				
Current Trouble Index	−0.087***	−0.090***				
($\boldsymbol{Q}_{t,v}$)	(2.94)	(2.68)				
Current Trouble Index	0.055	0.058*				
($\boldsymbol{Q}_{t+1,v}$)	(1.81)	(1.69)				
Trouble Index			0.004	0.010		
($\boldsymbol{Q}_{t,v-1}$)			(0.75)	(0.72)		
Trouble Index			0.022*	0.015		
($\boldsymbol{Q}_{t,v-2}$)			(1.63)	(1.06)		
KOYCK Distributed Lag					−0.030***	−0.026***
($\boldsymbol{KR}_{t,v}$)					(3.12)	(2.48)
KOYCK Distributed Lag					0.028***	0.025***
($\boldsymbol{KR}_{t+1,v}$)					(3.04)	(2.45)
GM	−0.018	−0.019	0.005	0.007	0.038	0.036
	(0.45)	(0.46)	(0.14)	(0.04)	(1.03)	(0.97)
Ford	0.004	0.004	0.011	0.013	0.028	0.028
	(0.12)	(0.11)	(0.32)	(0.10)	(0.80)	(0.78)
Chrysler	0.019	0.018	0.037	0.040	0.058	0.058
	(0.47)	(0.10)	(1.04)	(0.26)	(1.61)	(1.60)
Other	−0.034	−0.034	−0.034	−0.033	−0.019	−0.018
	(1.14)	(1.15)	(1.12)	(0.38)	(0.64)	(0.62)
Model Year (1986)	−0.197***	−0.197***	−0.181***	−0.181***	−0.224***	−0.224***
	(3.87)	(4.90)	(3.66)	(3.66)	(4.31)	(4.34)
Model Year (1987)	−0.149***	−0.149***	−0.128***	−0.128***	−0.191***	−0.192***
	(2.98)	(3.00)	(2.61)	(2.61)	(3.72)	(3.76)
Model Year (1988)	−0.079	−0.079	−0.062	−0.062	−0.272***	−0.273***
	(1.57)	(1.58)	(1.27)	(1.29)	(5.26)	(5.32)
Model Year (1989)	0.103**	0.102**	0.127***	0.127***	0.086*	0.085*
	(2.02)	(2.03)	(2.54)	(2.65)	(1.64)	(1.63)
Model Year (1990)	0.094*	0.094*	0.128***	0.128***	0.078	0.076
	(1.79)	(1.81)	(2.52)	(2.56)	(1.44)	(1.41)
Age (2)	−0.334***	−0.334***	−0.321***	−0.320***	−0.360***	−0.362***
	(6.37)	(6.42)	(6.23)	(6.269)	(6.69)	(6.75)
Age (3)	0.014	0.014	0.029	−0.029	−0.012	−0.015
	(0.26)	(0.26)	(0.57)	(0.55)	(0.22)	(0.28)
Age (4)	−0.254***	−0.254***	−0.238***	−0.237***	−0.423***	−0.428***
	(4.81)	(4.84)	(4.59)	(4.68)	(7.67)	(7.79)
Age (5)	0.217***	0.217***			0.219***	0.214***
	(4.14)	(4.17)			(3.94)	(3.86)
Age (2)×Model Year (1986)	0.402***	0.402***	0.387***	0.386***	0.419***	0.419***
	(5.65)	(5.69)	(5.53)	(5.55)	(5.75)	(5.79)
Age (2)×Model Year (1987)	0.393***	0.393***	0.377***	0.377***	0.284***	0.284***
	(5.61)	(5.64)	(5.46)	(5.37)	(3.96)	(3.98)

Table 3. Continued

Independent variable	Reputation		No reputation		KOYCK	
	(OLS)	(IV)	(OLS)	(IV)	(OLS)	(IV)
Age (2)×Model Year (1988)	0.550***	0.550***	0.536***	0.536***	0.757***	0.757***
	(7.79)	(7.85)	(7.72)	(7.71)	(10.48)	(10.55)
Age (2)×Model Year (1989)	0.362***	0.362***	0.344***	0.344***	0.393***	0.392***
	(5.05)	(5.09)	(4.87)	(4.89)	(5.35)	(5.37)
Age (3)×Model Year (1990)	−0.002	−0.002	−0.019	−0.002	−0.127*	−0.126*
	(0.03)	(0.03)	(0.27)	(0.27)	(1.73)	(1.74)
Age (3)×Model Year (1987)	0.236***	0.236***	0.217***	0.217***	0.297***	0.298***
	(3.35)	(3.38)	(3.12)	(3.13)	(4.13)	(4.16)
Age (3)×Model Year (1988)	0.185***	0.185***	0.169***	0.170***	0.395***	0.395***
	(2.62)	(2.64)	(2.42)	(2.42)	(5.45)	(5.48)
Age (4)×Model Year (1986)	0.577***	0.577***	0.563***	0.562***	0.767***	0.769***
	(8.09)	(8.14)	(8.02)	(8.35)	(10.50)	(10.58)
Age (4)×Model Year (1987)	0.551***	0.551***	0.532***	0.531***	0.757***	0.758***
	(7.84)	(7.89)	(7.67)	(7.48)	(10.51)	(10.58)
AGE (5)×Model Year (1986)	0.361***	0.361***			0.385***	0.386***
	(5.07)	(5.11)			(5.28)	(5.32)
Small	0.115***	0.115***	0.101***	0.102***	0.112***	0.112***
	(5.45)	(5.48)	(4.67)	(3.40)	(5.27)	(5.29)
Constant	0.200***	0.200***	0.155***	0.157	0.240***	0.242***
	(4.42)	(4.44)	(3.52)	(1.42)	(5.30)	(5.36)
Adjusted R^2	0.280	0.280	0.244	0.244	0.270	0.270
N	2050	2050	1869	1869	2050	2050

*, **, and *** represent significance at the 10, 5, and 1 percent level respectively. (Absolute value of t statistics).

significantly lower expected capital losses in order to compensate owners for higher expected maintenance costs.

The results also reveal the presence of learning in the market, with the arrival of favorable news partially mitigating a poor reputation's impact on the ***RCL***. The coefficients on the current trouble index variables, reflecting the responses to news arrivals, are all significant and of the expected sign.[15] The greater magnitude of the coefficients on $\boldsymbol{R}_{t,v}$, however, suggests that the positive price effects of favorable news are insufficient to offset reductions caused by a bad reputation.

In contrast, columns three and four of Table 3 provides results from the specification based on the expected cost function given in Eq. (5) where only the

[15] Recall that $\boldsymbol{Q}_{t,v}$ is the difference between the actual trouble index in the current period and the $\boldsymbol{R}_{t,v}$. Improvements in quality, therefore, are represented by negative values of $\boldsymbol{Q}_{t,v}$. Since the point estimates of the coefficients carry the same sign as those of $\boldsymbol{R}_{t,v}$, the marginal impact of these changes is to offset the effects of $\boldsymbol{R}_{t,v}$ on ***RCL***.

Table 4
Instrumental variables estimation of reputation model when quality changes

Independent Variable	Base Model	Quality Change[a]	No Quality Change
Historic Trouble Index ($\boldsymbol{R}_{t,v}$)	−0.1512**	−0.1472**	−0.0657
	(2.092)	(2.038)	(0.128)
Historic Trouble Index ($\boldsymbol{R}_{t+1,v}$)	0.1728***	0.1639***	0.0893
	(2.387)	(2.283)	(0.174)
Current Trouble Index ($\boldsymbol{Q}_{t,v}$)	−0.0897***	−0.0908***	−0.1080
	(2.681)	(2.552)	(0.872)
Current Trouble Index ($\boldsymbol{Q}_{t+1,v}$)	0.0581*	0.0658*	0.0250
	(1.687)	(1.764)	(0.322)
Intercept	0.1997***	0.2354***	0.1849***
	(4.438)	(3.947)	(3.998)
Adjusted R^2	0.280	0.281	0.281
N	2050	1104	946

*, **, and *** represent significance at the ten, five, and one percent level respectively. (Absolute value of t statistics). Coefficients on manufacturer, year, and age dummies are similar to those in column one of Table 3 and are not reported.

[a] In the regression, slope coefficients distinguish two groups of cars. Observations were defined as 'quality change' if the absolute value of the current trouble index $\boldsymbol{Q}_{t,v}$ exceeded 0.5; otherwise they are classified 'no quality change.'

trouble index of cars that are one year older is included.[16] This specification offers mixed results, but illustrates the benefit of including both historic and contemporaneous quality measures. The point estimates of the trouble index coefficients are only significant in one case and only at the ten percent level. Furthermore, both the adjusted R^2 and a Cox test of nonnested models support the specification in columns one and two as a better representation of the information structure for the U.S. market.[17]

Although our interest primarily lies in the parameter estimates for the historic and current trouble indices, the quality improvements that were widely publicized

[16] This is the specification chosen by EV to evaluate the use of public information in the German automobile market. It is presented here merely to show the advantage of the reputational specification in a market where quality is changing over time.

[17] The Cox statistic is distributed standard normal (see Greene, 1997). Testing the reputational specification chosen here over that chosen by EV reveals a value of the Cox statistic of 0.662, which is clearly less than the 5% critical value of 1.96. Testing the EV specification over the reputational specification reveals a test statistic of 1.72. Thus, there is some (weak) indication that the latter is the preferred specification.

during this period dictate allowing for individual manufacturer, model year, size and age effects. These variables, reported in Table 3, have a significant impact on the relative capital loss and are virtually identical across the various specifications. Additional controls for major style and engineering changes over the period were also incorporated in models not reported here. With the exception of small cars, however, the ***RCL*** did not differ across these various categories.[18]

Finally, the last two columns of Table 3 provide results from the Koyck distributed lag model. This alternative model offers strong support for the view of slowly changing beliefs and indicates that past quality is an important determinant of a vehicle's ***RCL***. The maximum likelihood estimate of λ is 0.90, suggesting a rather gradual dissipation of weights placed on earlier information.[19] In fact, the maximum likelihood estimate of 0.90 implies that the median lag, or the time required for past information to be discounted by 50%, is 6.5 years.

If agents slowly adjust their beliefs over time, the above results should hold best under circumstances where quality changes have been the most pronounced. To test this hypothesis, a dummy variable equal to one if the absolute value of the current trouble index, $\boldsymbol{Q}_{t,v}$, exceeded 0.5 was interacted with the four informational variables and included in the basic specification.[20] Coefficient estimates of the reputational variables are reported in Table 4, together with the ones from Table 3 for comparison purposes.[21]

The results in columns two and three of Table 4 are striking and indicate that the strongest reputational and learning effects occur in that subsample where the largest quality changes have been made. When substantial quality improvements have been made by the Big Three, changing beliefs are diffusing throughout the market. Nevertheless, as reflected in market prices, expectations about new and improved cars still suffer as a result of quality control problems and name brand association from previous models. In contrast, for automobiles where little or no quality change occurred, information variables play no significant role in the determination of the ***RCL***. For the latter subsample, quality is invariant over time

[18] Size consists of small, compact, midsize, and large cars as classified by *Consumer Reports*. Style and engineering changes were inferred from *Wards Automotive Yearbook* (Ward's Communications, 1985) which provides a written description of model makeovers. Following Kwoka (1993), a model was considered 'new' if it had completely new body panels or was newly engineered. Allowing for a common depreciation rate across all size and design categories resulted in an F statistic of 7.29, which exceeds the critical value of 2.37. The specification in Table 3 resulted in an F of 1.67.

[19] The Koyck parameter λ was estimated by an iterative grid search. For each $\lambda = 0.01, 0.02, ..., 1.00$, the Koyck reputation variable, KR, was constructed and least-squares was fitted to the Eq. (10′). The maximum likelihood estimate of λ, or equivalently the value that minimized the sum of squared errors, was found to be 0.90.

[20] A range from 0.3 to 0.8 of thresholds for the absolute value of the current trouble index, $\boldsymbol{Q}_{t,v}$ were also tested with no significant change in the results.

[21] The significance levels and values of the point estimates of the other control variables in the model varied little from those in Table 3. These estimates are omitted to save space.

and prices fully capitalize the market value of quality. In short, learning appears to occur where it is most productive.

6. Further evidence from U.S. and Japanese twins

The evidence presented to this point relies on an admittedly imperfect quality index, but can be supported in a more direct way. In recent years, several car models have been produced largely in the U.S. under joint venture arrangements between American and Japanese automakers, for example the Chevrolet Spectrum and Isuzu Imark. These products might be described as 'identical twins separated at birth', and it is interesting to see if the previous hypotheses are corroborated in their respective resale prices. In addition, the U.S. automakers have for years marketed twins under alternative trademarks, such as the Buick SkyHawk and the Chevrolet Cavalier.

There exists at least two reasons *a priori* for expecting that the brunt of reputational adjustment has fallen on U.S. producers. First, as discussed in Section 2, ample evidence suggests that U.S. producers had poor quality products during the late 70's and early 80's. Second, it also suggests that the U.S. producers have made substantial efforts toward improving quality. In contrast, the Japanese producers have maintained consistent (higher) quality prior to and throughout the sample period. Thus, while the resale prices of U.S.–Japanese twins should reveal the magnitude of the American car-makers' adverse reputation for quality, the resale pricing of U.S.–U.S. twin pairs provides data on a reputationally-constant control group. Such pairs are not perfect substitutes. However, they largely remove substantial, objective differences in car quality and allow one to see whether any signs of adverse reputational effects are present in the pricing of U.S. twins. To account for the slight differences that are associated with variations in the reported models, the prices are measured at each age relative to the new car prices.[22]

[22] In an ideal setting, direct price comparisons between 'identical' twins would easily reveal reputational effects. To control for small variations in features of each pair, however, used car prices are scaled relative to their respective new car price. This scaling may introduce noise into the dependent variable if new car pricing decisions are strategically different between U.S. and Japanese producers. For example, it appears that U.S. car makers would be more likely to engage in discounting given the poor U.S. reputation and the voluntary import restrictions during this period. If new car prices are more heavily discounted for U.S. cars than Japanese, other things equal, the dependent variable, **DIFF**, would tend to be biased downward, implying that our estimate of the reputational penalty suffered by the U.S. twin is understated.

Used-car price data on twins include twenty-four observations on U.S. cars paired with essentially identical cars carrying a Japanese trademark, and thirty-five cases of U.S. cars paired with another U.S. product.[23] Each twin is observed for up to five years after the model year. The dependent variable for a pair {a, b} is **DIFF**, the difference in percentage depreciated value, defined as $100*[(P^t/P^{\text{new}})_a - (P^t/P^{\text{new}})_b]$, where P^t is the resale price at age t and P^{new} is the new car price.[24]

The least-squares results are shown in Table 5, including regressions on the sample of all vintages combined as well as for each vintage separately. First, there is a clear and systematic tendency to discount the U.S. twins in the resale market, despite their close similarity in objective characteristics. The estimated coefficient on the indicator variable **U.S.–Japanese Twin** confirms that U.S. cars are significantly discounted relative to their Japanese twin. The market can be seen as producing an average discount of 5 percent for trades in U.S. models in the first five years relative to cars sold under the Japanese trademark.

A further hypothesis is that prices are more likely to reflect consumer learning when learning has the biggest payoff, i.e. in circumstances where the quality of newer models is substantially better (worse) than in the past.[25] To see this point, observations were identified based on whether the reported ratings over the life of the U.S. car were favorable or unfavorable. The indicator variable **IMPROVED** is a dummy variable set to one if **U.S.–Japanese Twin** equals one and the current trouble index for the U.S. twin was less than -0.5. When the relative discount for U.S. cars was compared for the two groups, the hypothesis that the more favored models were priced closer to the Japanese is borne out for three of the five years.

The results confirm that strong reputational and learning effects occur in the market for U.S. automobiles. While avoiding the difficulty of measuring auto quality precisely, the twins analysis is consistent with our results in Section 5 that suggest used-car price adjustments are driven by information disclosures that occur via publications like *Consumer Reports* and other media. Finally, it is interesting to note that, in this sample, the evidence does not show that consumers learn to recognize the twin relationship during the first five years. Thus, consumers are

[23] To be considered twins, the two vehicles had to have identical mechanical specifications. These specifications, reported in Consumer Reports, include weight and front/rear distribution, tire size, steering factor, turning circle, engine displacement, horsepower, transmission and forward speeds, gear ratio, r.p.m. per mile, and fuel tank capacity.

[24] For observations on U.S.–Japanese twins, the Japanese price ratio is subtracted from the U.S. one. Consequently, we expect that the coefficient on an indicator variable for U.S.–Japanese twins would be significant and negative in the regression.

[25] Theoretical analyses have suggested that sellers may adopt a strategy of ‘milking’ a high quality reputation in dynamic games. During the period studied here, however, the quality of cars was moving in only one direction, higher, so the test can only be carried out one-sided.

Table 5
OLS regressions on the depreciation of twin models

	Independent Variable	Estimated Coefficient
All Ages Pooled	U.S.–Japanese Twin	−4.963***
($N=264$, $R^2=0.180$)		(7.709)
	Improved	2.649***
		(2.633)
	Constant	−0.105
		(0.274)
One Year Old Cars	U.S.–Japanese Twin	−3.364***
($N=58$, $R^2=0.104$)		(2.388)
	Improved	0.358
		(0.156)
	Constant	0.442
		(0.539)
Two Year Old Cars	U.S.–Japanese Twin	−4.274***
($N=58$, $R^2=0.139$)		(2.980)
	Improve	3.684
		(1.580)
	Constant	−0.596
		(0.713)
Three Year Old Cars	U.S.–Japanese Twin	−5.456***
($N=58$, $R^2=0.220$)		(3.948)
	Improved	4.612**
		(2.053)
	Constant	−0.155
		(0.192)
Four Year Old Cars	U.S.–Japanese Twin	−6.541***
($N=52$, $R^2=.0305$)		(4.673)
	Improved	4.665**
		(2.122)
	Constant	−0.253
		(0.292)
Five Year Old Cars	U.S.–Japanese Twin	−5.317***
($N=34$, $R^2=0.300$)		(3.313)
	Improved	−0.036
		(0.017)
	Constant	0.129
		(0.125)

*, **, and *** represent significance at the ten, five, and one percent level respectively. (Absolute value of t statistics).

Note: The dependent variable in Table 5, DIFF, is defined for each twin pair {a,b} as $100^*[(P_t/P_{new})_a - (P_t - P_{new})_{b]}$. When a pair is a U.S. Japanese twin, DIFF is ordered with the U.S. price in the first term, i.e. $100^*[(P_t/P_{new})_{US} - (P_t - P_{new})_{Japanese}]$, whereas the ordering is random for U.S.–U.S. twins. U.S.–Japanese Twin is a dummy variable equal to 1 if the pair is a U.S.–Japanese twin. Improved is a dummy variable equal to 1 if U.S.–Japanese Twin equals 1 and the Current Trouble Index for the U.S twin was less than −0.5.

slow to change their beliefs about the comparable quality of twin cars during periods following the establishment of a bad reputation.

7. Conclusions

With durable goods like automobiles, the process of recovering from a bad reputation may be slow and costly. This paper examines reputational adjustments over time and how they affect pricing in resale markets. In markets for used autos, agents are imperfectly informed, but they can choose to learn about quality by relying upon intermittent public surveys. For this study, annual data on used cars from the 1980's provide a unique setting to study changes in reputation for quality.

The results indicate how market prices respond to public reports of quality. We find that adverse reputation has reduced the prices of U.S. automobiles through 1990. In those instances where the U.S. model can be matched to a Japanese twin, used car prices for the U.S. model are approximately five percent lower, on average. During the last decade, substantial changes have occurred in the market's perception of U.S. cars. These changes were still underway as of 1990, and it may be some time before the lingering effects of the Big Three's quality control problems of the 1980's are erased.

What is the depreciation rate of a bad reputation for low quality autos? An implication of the Koyck model is that adverse quality reports are given partial weight by traders even after a lag of five years. While it would be interesting to determine more precisely the time necessary to overcome a bad reputation, our data are restricted to a brief period when U.S. car makers suffered from an adverse quality reputation and had not completely overcome it by the end. Presumably, if the depreciation rate of a good reputation were low enough, it might induce top quality producers to 'milk' their reputation from time to time. It would appear, however, that such 'milking' has not occurred in recent years in the auto business. Rather, objective data show that there is a fierce battle over quality improvement worldwide, producing a continuous reduction in quality defects in car manufacturing.

Our findings have implications for the welfare of the U.S. auto industry in addition to traders in the market for used automobiles. Evidence that the public is influenced by the quality of models from previous years when forming their beliefs about current or future quality suggests that U.S. manufacturers, who have made substantial investments in quality improvement, will receive a lower return on this investment until the public fully accepts the new quality level as fact. That these costs are high is evident in GM's effort to establish separate production and marketing divisions for Saturn, widely seen as an attempt to disassociate the new line of products from the parent company's poor reputation.

Acknowledgements

Authors thank the anonymous referees, Kislaya Prasad, Tim Sass and participants in the Quantitative Methods Workshop at FSU for their input.

References

Consumer's Union, 1986–1992. Consumer Reports. Consumer's Union, New York, NY.

Edmund's Publications, 1985–1993. Edmund's Used Car Prices. Edmund's Publications Corporation, Los Angeles, CA.

Emmons, W., von Hagen, J., 1991. Asset prices and public information: An empirical investigation in the market for automobiles. European Economic Review 35, 1529–1542.

Fomby, T., Hill, R.C., Johnson, S., 1984. Advanced Econometric Methods. Springer-Verlag, New York.

Greene, W., 1997. Econometric Analysis, 3rd ed. Prentice-Hall, NJ.

Kennedy, P., 1992. A Guide to Econometrics, 3rd ed. MIT Press, Cambridge, MA.

Klein, B., Leffler, K., 1981. The role of market forces in assuring contractual performance. Journal of Political Economy 89, 615–641.

Klein, E., 1993. Time to buy an American car?. D and B Reports 42, 34–37.

Kwoka, J., 1991. Automobiles: Overtaking an oligopoly. In: Deutch, L. (Ed.), Industry Studies. Prentice Hall, Englewood Cliffs, NJ, pp. 63–84.

Kwoka, J., 1993. The sales and competitive effects of styling and advertising practices in the U.S. Auto Industry. The Review of Economics and Statistics 75, 649–656.

Shapiro, C., 1983. Premiums for high quality products as returns to reputations. Quarterly Journal of Economics 98, 659–680.

Spencer, P., 1992. The comeback of the American car. Consumer's Research 75, 11–13.

Ward's Communications, 1985–1990. Ward's Automotive Yearbook. Ward's Communications, Detroit, MI.

Wykoff, F.C., 1973. A user cost approach to new automobile purchases. Review of Economic Studies 40, 377–390.