Advertising and the evolution of market structure in the US car industry

Book Section

*ADVERTISING AND THE EVOLUTION OF MARKET STRUCTURE IN THE US CAR INDUSTRY DURING THE POST-WAR PERIOD**

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ABSTRACT

This paper focuses on a single simple stylized fact which stands out from the post-war history of the US car industry, namely that industry concentration fell just at the same time as industry advertising expenditures rose sharply. Since both events were almost certainly caused by the entry and market penetration of (largely) foreign owned car producers, this stylized fact raises interesting questions about whether – and if so, how – advertising affects entry. We use a model of consumer switching behaviour to help interpret the facts. The model predicts a simple linear association between market and advertising shares (which we observe fairly clearly at two different levels of aggregation in the data), and provides the basis for arguing that advertising can facilitate entry, but only for finite periods of time.

JEL Classification: L10, L62

I. INTRODUCTION

It is widely believed that an industry with high levels of sunk costs is likely to be more concentrated than one with lower levels of sunk cost. This proposition is sometimes taken to suggest that an increase in sunk costs will lead to rise in concentration. When expressed in this form, this proposition would, for example, lead one to expect that the escalation of advertising which occurred at the end of the 1970's in the US Car industry – an increase of more than eight fold from the early middle 1970s through to the late middle 1990s -- would have INCREASED the level of industry concentration. In fact, concentration in this industry actually fell during that period. The paper attempts to explain how this unexpected outcome came to pass.

To understand what might underlie this puzzle, one needs to recognize that advertising can have two rather different effects on competition. On the one hand, advertising expenditures are both fixed and (usually) sunk, and this serves to limit entry and reduce the number of firms that can profitably operate in a market. On the other hand, advertising can be used by firms to attract attention to their products and induce switching behaviour by consumers. It is, therefore, conceivable that advertising can also facilitate entry, and that entrants who attempt to advertise their way into a market may partially or totally displace incumbents, gaining enough sales revenue to cover their fixed costs even in a stagnant market. If this happens – if entrants manage to capture a noticeable share of the market by advertising -- and if incumbents respond to advertising led entry by increasing their own advertising, then one will observe both an increase it total industry advertising and a fall in market concentration. Roughly speaking, this is what seems to have happened in the US car industry in the post-war period.

In this paper, we develop a simple econometric model of competition in a market where advertising is the main competitive weapon. The heart of the model is a relationship between market and advertising shares which results from a (not entirely implausible) model of buyer behaviour that may accurately describe patterns of demand in markets for experience goods where firms do not compete on price but do compete on advertising and in other ways. The particular relationship that we focus on is interesting because it can, in principle, sustain many equilibria: if only advertising shares matter, market shares will be the same if all firms spend £1 or £1m each on advertising. To pin down this

ambiguity, we develop a relatively simple specification of advertising choice which helps to account for the sharp escalation in advertising expenditures which occurs during advertising wars. Taken together, the two equations link the activities of firms during an advertising war to the subsequent evolution of their market shares and will, therefore, help to explain changes in market structure during and after the advertising war.

The structure of the paper is as follows. In Section II below, we spell out the model of the relationship between market and advertising shares that we will use in the empirical analysis, and examine how to empirically model the dynamics of advertising competition between firms. In Section III, we apply these two interrelated models to data on the US Car industry in the post-War period. Since most of the entrants involved in these events were foreign owned producers, the simplest level at which one can observe this competitive process is by aggregating the data into two "players": all domestic producers and all foreign producers. We report results at this level of aggregation, and then show that they are also observable at the firm level by applying the models to seven leading firms in the market (three domestic and for foreign owned). Section IV summarizes the results and notes a number of caveats.

II. MARKET SHARES AND ADVERTISING WARS

To understand how an advertising war might lead to changes in market structure, we need to understand the relationship between advertising and market shares, and then we need to model the dynamics of how advertising shares evolve over time.

Advertising shares and market shares

The link between advertising and market shares depends on consumer behaviour, and so we begin there. Consider the following stylization of consumer choice. Cars are an experience good, but the characteristics of particular models change more often than particular consumers purchase them. As a consequence, there is only a limited amount of relevant (i.e. experiential) information available to consumers prior to purchase, and the information that a user accumulates about a particular car is always incomplete. Accurately measuring the user value of some pertinent characteristic (e.g. durability) requires extensive usage, and changes in characteristics over time means that this years new car is not exactly

comparable to last years version of the same car. The implication is that dissatisfaction with last year's car will not necessarily lead to switching behaviour when the consumer purchases a new car this year; nor, for that matter, will satisfaction necessarily guarantee repeat purchasing.

Some notation will help us to express this more precisely. Suppose that car j has a level of "quality" λ_j. By construction, λ_j measures "quality" in terms of repeat purchase: a "high quality" car will generate a higher level of repeat purchasing than a "low quality" car. A consumer who purchases j in t will, by period t+1, have formed a view about whether s/he is satisfied or not. Suppose that if s/he is satisfied, s/he will repeat the purchase again in t with probability $(1 - 1/\lambda_j)$; otherwise s/he will switch to another car with probability $1/\lambda_j$. The key question is what determines the choice of a new car if the consumer elects to switch in period t+1. If firms do not compete on price (or if price matching occurs and eliminates all quality adjusted price differences between different brands) and if quality is difficult to observe with any accuracy, then consumers are likely to turn first to the alternatives which they are most aware of. There are many ways to measure "awareness", but one obvious possibility is in terms of relative advertising intensity. If the level of advertising of car k, A_k, is high relative total market advertising, then many consumers are likely to be aware of car k and some number of then will opt for k if they become dissatisfied with car j (and more will do so than for some other car i which is advertised less intensively than car k).[1] If all consumers behave in this way, it turns out that in the long run market shares will be proportional to advertising shares,

$$(1) \qquad Q_j/Q = \theta_j \, A_j/A,$$

where Q_j is the output of firm j, A_j is total advertising by firm j, Q is total industry output , A is total industry advertising and $\theta_j \equiv \lambda_j/\Sigma \, \lambda_j(A_j/A)$ is a measure of the relative "quality" of car j.[2]

It is worth making three observations about this relationship. First, advertising has both a pro and an anti-competitive effect in this model. On the one hand, an entrant who can come in and claim a large enough advertising share can claim a place in the market. However, as that entrant advertises and as incumbents respond, the total volume of

advertising in the market rises, and this raises the cost of "acquiring" an advertising share of any given size. Clearly, this disadvantages entrants, and closes the window of opportunity which had originally facilitated their entry. In other words, the dynamics of entry competition may mean that the pro-competitive effect of advertising is transitory; i.e. that early entrants engineer a deterioration in initially favourable market conditions whihc discourages or deters subsequent entrants.

The second observation is that advertising does not work in a vacum. In this model, advertising attracts buyers who are dissatisfied with their existing choice: the driver of switching is product quality, not advertising. A firm that advertises (relatively) heavily but sells a poor quality product will attract many new buyers (who are dissatisfied with other low quality products) but will also lose many existing buyers (who become dissatisfied with the low quality of the product). By contrast, a high quality firm that does not advertise will retain most of it's existing customers but will not attract many new ones, and it's market share may be higher or lower than a low quality/high advertising firm (it's customer churn will, however, be lower).The model predicts that two firms with the same market share but different levels of quality will, of necessity, display different levels of advertising, and that the low quality/high advertising firm will experience more churn amongst it's consumers than the higher quality firm will.

Third, it is clear from (1) that there are, in principle, many different vectors of advertising across firms which sustain the same vector of market shares: if the levels of advertising by all firms in any particular equilibrium were multiplied by the same amount, market shares would remain unchanged. This means that the profits of all firms at any particular equilibrium could be improved if the advertising of each fell by the same proportional amount (since this would have no effect other than reducing the fixed costs of each firm). It is not entirely clear how firms might bring about this reduction, although it is at least conceivable that a formal agreement might work. More likely is some kind of tacit understanding. Suppose that an industry is composed of a group of incumbents who are undisturbed by entry and display relatively constant market shares over a long period of time. In such a setting, mutual awareness and a common interest in keeping advertising expenditures under control might yield an outcome like (1) in which market shares are supported by relatively modest levels of advertising by each and every incumbent firm. The interesting thing about this outcome is that it is liable to be rather unstable for one or both of

two reasons. First, the more successful such a tacit (or, perhaps, formal) understanding is in reducing total industry advertising, the more likely it is (ceteris paribus) that entrants will be attracted to the market, since the lower is total industry advertising, the less expensive it is to "purchase" market share through advertising. This, of course, may set off an advertising war as incumbents respond to the encroachments of entrants. Second, tacit understandings are not always proof against the competitive ambitions of incumbents even when entry is blockaded, and attempts to surreptitiously increase market shares by advertising more than rivals expect may (also) lead to an advertising war if the transgression is spotted.

Our final task is to translate (1) into an empirical model. Consumer behaviour of the type discussed above only generates (1) as a long run relationship, and it is easy to believe that (1) might not literally hold at every data point even if the model is correct. One easy way to generalize (1) to allow for this is to write it in an error correction framework,

$$(2) \qquad \Delta MS_j(t) = \varphi_0 MSj(t-1) + \varphi_1 ASj(t-1) + \varphi_2 \Delta MS_j(t-1) + \varphi_3 \Delta AS_j(t-1) + \mu_j(t),$$

where $MS_j \equiv Q_j/Q$, $AS_j \equiv A_j/A$ and $\mu_j(t)$ is a while noise error. Since, in equilibrium, all of the first difference terms are zero, (2) yields an estimate of $\theta = -\varphi_1/\varphi_0$. However, it may be unwise to assume as a matter of course that θ is a constant: very large shifts in advertising shares between firms with very different quality levels may cause θ to drift over time. In the absence of any observed measures of "quality", the simplest extension of the model that allows one to control for this would be to let the parameter φ_1 evolve over time. If, for example, φ_1 were a linear function of a deterministic time trend, then (2) would include an additional term, $AS_j(t-1)*T$, where T is the time trend.

Advertising wars

The relationship captured in (1) is behavioural: it is a consequence of the fact that consumers behave in certain way and does not result from decisions by firms. In a sense, it is analogous to a conventional demand curve, and profit maximizing firms will accept it as a constraint when they choose optimum levels of advertising.[3] In general, the Dorfman-Steiner condition suggests that the optimal choice of advertising will set the level of

advertising to be some proportion of sales, the particular proportion depending on the price and advertising elasticities of demand. This turns out to be the case even when the kind of consumer behaviour which underlies (1) occurs. Schmalensee, 1976 and 1978, has shown that in this case a Nash equilibrium in advertising yields a vector of optimal levels of advertising, A^*_j, which are proportional to output choices, Q_j (the factor of proportionality depends in this case on λ_j and on the costs of producing higher quality products). If, as before, we do not assume that all of the data reflect optimum choices, then a natural way to express this first order condition is as

$$\Delta Z_j(t) = \alpha_0 + \alpha_1 Z_j(t-1) + \varepsilon_j(t), \tag{3}$$

where $Z_j \equiv (A_j/Q_j)$, the ratio of advertising to sales and $\varepsilon_j(t)$ is a white noise error. (3) allows actual advertising choices to (temporarily) depart from optimal choices (as might occur, for example, if there were adjustment costs associated with scaling an advertising campaign up or down). The quantity $(-\alpha_0/\alpha_1)$ is an estimate of the equilibrium advertising sales ratio for firm j, and, as before, it is not necessary to assume that it is constant over time: α_0 could be modelled as depending on a vector of observables, or a time trend.

Equation (3) is built on relatively simple and static foundations, and it is unlikely to be an accurate description of decisions about advertising spending when entrants are challenging incumbents and the total volume of advertising in the market is rising rapidly. It is difficult to develop a model describing how firms make decisions during an advertising war, for, in these circumstances, firms are liable to be heavily influenced by expectations about the actions of their rivals and these are not always well grounded in the fundamentals. However, the distinguishing feature of an advertising war is almost certainly that firms will change their advertising spending in response to the actions of their rivals more or less regardless of current levels or changes in their sales. Indeed, (3) suggests that it will be particularly easy to spot when a war of this type is occurring if firm j increases it's advertising despite a fall in sales.

A natural way to build this insight into a model is to start with the model of optimal advertising choice in the absence of a price war, and then generalize it to allow firm j to respond directly to the advertising of it's rivals. This suggests a formulation such as

(4) $$\Delta Zj(t) = \alpha_0 + \alpha_1 Z_j(t-1) + \alpha_2 \Delta R_j(t-1) + \varepsilon_j(t),$$

where $\Delta Rj(t-1)$ is the change in the advertising activities of j's rivals. Note that we assume that it takes one period for firms to respond to the actions of rivals.[4] In essence, this specification allows for a much longer, much more systematic departure from equilibrium than (3) allows, and associates it with the actions of particular rivals. At equilibrium, $\Delta Zj(t) = \Delta R_j(t-1) = 0$, and so $A_j = (-\alpha_0/\alpha_1)\, Q_j$, which is consistent with the first order conditions describing the optimal choice of advertising in "normal" (i.e. non-war) conditions.

To give this extension of (3) some substance, one must specify $R_j(t)$. Possibly the simplest specification is to write $\Delta R_j(t-1) = \Sigma \omega_k \Delta A_k(t-1)$, where the ω_k are weights reflecting the degree to which each rival k presents a substantive competitive challenge to j. This specification supposes that firm j responds directly to any change in the advertising of it's various rivals k, a course of action which seems rather naive. A more sophisticated firm might try to predict what it's rivals are likely to do, and then respond only to departures from that prediction; i.e. it may respond only to "surprise" changes in the advertising of it's rivals. The thinking here is that firm j will understand (and, therefore, incorporate) the equilibrium behaviour of it's rivals j in it's own (equilibrium) advertising choices, but systematic departures from equilibrium behaviour by rivals is taken to indicate the existence of a "new regime" in which advertising is being chosen strategically by rivals to increase their market shares. One way to capture this is to imagine that firm j uses (3) to generate a predicted value of Z_k -- call it $Z_k^*(t)$ -- for each rival k, and then let $\Delta R_j(t) = \Sigma \omega_k [Z_k(t) - Z_k^*(t)]$. In this specification, equilibrium requires two conditions: $A_j = (-\alpha_0/\alpha_1)\, Q_j$ and $Z_k(t) = Z_k^*(t)$; i.e. no firm is surprised about the behaviour of it's rivals.

III. THE US CAR INDUSTRY IN THE POST-WAR PERIOD

The data that we will be using describes the evolution of market shares in the post-War US Car industry. Our first step is to discuss the data and provide an overview of events. Then we look at the relationship between market shares and advertising shares using (1) and (2), aggregating the data into a particularly simple form that reduces the industry to two players: domestic and foreign firms. Not only is this a roughly accurate characterization

of the different groups of firms responsible for the events we observe, but using a two player model makes it much easier to understand the dynamics of the market. We then disaggregate the data, and re-estimate the model on firm specific data for seven of the largest firms in the market (three domestic firms and four foreign firms). This enables us to enrich our account of the dynamics, but it also shows just how robust the two player characterization is. Finally, we turn to an examination of the dynamics of advertising over the period.

The data[5]

Two features of the post-war evolution of the car market over the period 1954-1996 that we are most interested in here are displayed on Figure I. The first is that during the first 15 or so years of the sample period total industry advertising intensity was stable at relatively low levels (advertising was about .035% of sales on average). It crept up gently through to the middle 1970's before escalating very rapidly through the 1980's and into the 1990s (the level of advertising expenditures rose by a factor of 8.73 between 1976 and 1996). The second interesting feature of the data is that advertising intensity and the three firm concentration ratio (defined here as the sum of the shares of Ford, GM and Chrysler) are negatively correlated over the period. Much the same correlation applies between advertising intensity and the Herfindahl. The correlation between total industry advertising levels and these two concentration measures is (respectively): -.8622 for the three firm concentration ratio, and -.7529 for the Herfindahl, while that between each concentration measure and industry advertising intensity is: -.7212 and -.8882 respectively.

It is, of course, possible that the apparent correlation between concentration and advertising shown on Figure I is spurious. The most obvious possibility is that market size might have increased during the period, making increases in advertising profitable for firms, and deconcentrating the market by creating new market segments for fringe or entrant firms to colonize. However, there is no easily discernible upward or downward trend in total industry sales from the mid-1970s until the end of the period (although there are very substantial cyclical fluctuations). The correlations between market size and the two measures of concentration are: -.4931 and -.3367 (which is what one expects), while the correlation between total sales and total advertising is only .1703 (which is more surprising).

In fact, it is more likely that the events described on Figure I were caused by entry. As is well known, this period saw foreign owned car makers enter the US market on a fairly large scale and make serious inroads into the share of the top three US firms. To see the role played by these entrants, it is necessary to disaggregate the data. We focus on two groups: the three US producers (GM, Ford and Chrysler, collectively labelled "*domestic*" producers) and the major non-US (i.e. "*foreign"*) owned players (specifically: Honda, Volkswagon, Nissan and Toyota). These two groups do not entirely exhaust the population of US Car producers and, as a consequence, the sum of their market and/or advertising shares do not sum to unity (although they averaged .97 and .95 respectively throughout the period).[6] At the beginning of the period, the collective market share of domestic firms was above .95, but by the end of the period it had fallen below .65. The Herfindahl fell from 5465.9 to 1773.5, while the number of domestic producers fell from 7 to 3. Foreign producers, on the other hand, began making serious inroads into the collective share of domestic players during the1950s. By 1970, their share of the market was 14%, and it rose steadily to about 35% at the end of the sample period. This invasion was led by Volkswagon, who established themselves in the US more quickly than the others, and was (jointly with Honda) the leading foreign player (from amongst the group under consideration) at the end of the period. The last two substantial entrants covered by our data were Mazda and Mitsubihshi, whose presence in the market was felt from the mid 1980's on.

As it happens, the sharp escalation in industry advertising also dates from the late 1960s, and it occurred because both domestic and foreign owned firms increased their advertising (the correlation between the advertising of these two groups of firms is .9862). The basic story tells itself on Figure II. Both foreign and domestic firms had similar advertising intensities in 1970 (.003), but by 1973 foreign firms were advertising noticeably more intensively (.0056 versus .0039, rising to .011 versus .0068 in 1976). Domestic firms responded and both had similar advertising intensities in 1981 (about .015) and again in 1985 (.023)), but after 1981 and again after 1985 foreign firms raised their advertising intensities above those of domestic rivals. Domestic firms finally caught up in 1995 and 1996, and advertised more intensively than their foreign rivals (.080 versus .078, and .093 versus .072) in the last two years of the sample period. It is difficult to be absolutely sure, but this pattern is certainly consistent with the view that the advertising war which developed was initiated and sustained mainly by the aggressive market penetration goals of foreign firms. The interesting thing about this escalation in advertising is that the advertising of foreign based

firms rose with their total sales (the correlation is .8156) while that of domestic based producers also rose despite a fall in their sales (the correlation is -.3976).

Market and advertising shares for domestic and foreign firms

The model outlined in (1) and (2) in Section II above suggests that these movements in concentration and advertising were causally related, with the key relationship being a simple linear relation between market shares and advertising shares. When applied to aggregated data on the top three US producers, this market share equation is, of course, a concentration equation.

The basic features of the story told in Section II are very clearly evident in the data, as is evident from Figure III. The simple correlation between advertising and market shares for both domestic and foreign firms is .9159 and .9590. Both series fell over time for domestic firms and both rose for foreign firms. A naive exploration of the model developed in Section II might start from equation (1). Simple linear regressions of market shares on advertising shares for domestic firms and foreign firms yield high R^2s (.84 and .92), and the estimates of the co-efficient on advertising shares (which are naive estimates of θ) which these regressions produce are .76 and .79 for domestic and foreign firms respectively (t-values are 14.6 and 21.7). Including time trends in these regressions causes the co-efficients on advertising share to fall to .17 and .11 respectively, but both time trends are very significant. Further, the co-efficient on the domestic (foreign) trend is negative (positive), which is consistent with the view that the quality of foreign cars rose steadily throughout the period. Given the fact that both series trend, this is not a surprise. The implication is that at this level of aggregation, it may be easy to confound the effect of advertising share on market share with any kind of secular change (such as a change in "quality") which might be accurately described using a linear time trend.

One of the more serious problems with the naive regression is a concern that advertising shares might be correlated with the residual (e.g. because of simultaneity bias), leading to biased estimates of θ. We explored several different empirical models of advertising shares, using each to develop instruments for advertising shares. The best model that we developed included two lagged dependent variables plus the growth in US GDP,

total car production and total industry advertising. Aside from the lagged dependent variables, the lagged growth of domestic and foreign advertising were the most notably significant variables. Almost all of the equations of this type that we ran provided pretty good fits. Using these equations to generate instruments yielded estimates of θ which were very close to those generated by OLS regressions on the naive model (1): θ = .731 (rather than .763) for domestic firms, and .840 (rather than .786) for foreign firms. Much the same results were observed in all the experiments of this type that we conducted, and we conclude that the several shortcomings of the naive estimates of θ probably do not include the problem of simultaneity bias.

As noted in Section II, there is an implicit assumption in (1) and (2) that the returns to advertising are constant. Since domestic firms are much larger and advertise much more than foreign firms, it is possible that at least some of the movements in market share that we are observe are driven by diminishing returns (for domestic firms) or increasing returns (for foreign firms). An easy way to explore this possibility is to regress the log of market shares on the log of advertising shares. This yields naive but statistically significant estimates of .966 and .916 respectively on the returns to scale parameter (denoted e in footnote #2), which is difficult to distinguish from constant returns. When a time trend is included, both co-efficients fell but remained significant. As before, the time trend has a positive slope for foreign firms and a negative slope for domestic firms. At the very least, these regression suggest that the effects of advertising on market shares advertising does not display increasing returns.

Since (2) is most reasonably thought of as a long run relationship, the error correction representation (2) may be more appropriate than naive regressions based on (1). Table I displays estimates of two versions of (2). Recall that, in equilibrium, market shares and advertising shares are linked by a factor of proportionality, θ = -φ/φ. In regressions (i) and (iii), this factor of proportionality is assumed to be constant; in (ii) and (iv), it is allowed to follow a deterministic trend (which gives rise to a term which is the product of advertising share and a time dummy). Since θ is a measure of "relative quality", this slight generalization allows for quality differences between firms to vary over time. Focussing first on (i) and (iii), both of the lagged market and advertising shares variables are significant, and together imply estimated values of θ = .723 and .779 for domestic and foreign firms

respectively. These estimates are very close to those obtained from the naive regressions based on (1) discussed above. Regression (iii) displays mild signs of mis-specification and suggests that the specification shown in (ii) and (iv) might be more appropriate. Unsurprisingly, the inclusion of the interactive variable reduces the t-value on lagged advertising shares, but it is clear that (iv) in particular cannot be simplified to (iii). (ii) and (iv) imply that: $\theta = .442 - .00689*T$ for domestic firms, and $\theta = .292 + .0118*T$ for foreign firms (where T is a linear time trend). The implication of these estimates is that domestic firms were initially perceived to be of higher quality, but that after 1960 the relative quality ranking reversed.

To assess the power of this particular empirical specification, it is important to compare it to something reasonably meaningful. In the case of (1) and (2), this could be the null that changes in market shares are random, meaning that market shares follow a Gibrat process. It is easy to reject this particular null. However, market shares are bounded between zero and unity, and an alternative null hypothesis is that all co-efficients save that on lagged market share are zero (this is observationally equivalent to assuming that market shares follow an AR(1) process). Here the decision is slightly more marginal, but still reasonably clear. One way or the other, using advertising shares to explain market shares is a noticeable improvement on just presuming that market shares vary randomly or follow a simple autoregression.

The other way to assess the model is to explore a range of obvious variants. We did this in two ways. First, we experimented by adding a range of other variables in (i) – (iv), including: the rate of growth of US GDP, the rate of growth of the consumer price index and the producers price index, the rate of growth of industry output and of total industry advertising, the log of market size and dummy variables identifying the arrival of the first major foreign entrant (Volkswagon) and the last two (Mitsubhi and Mazda). Although several of these variables had a statistically significant impact on market shares, in no case did the inclusion of one or more of them lead to any qualitative differences in the inferences drawn from Table I: there seems to be a fairly close and fairly robust linear association between market shares and advertising shares for domestic and foreign firms.[7] Working in the other direction yields much the same conclusion: namely that the estimates shown in (i) – (iv) are fairly robust. Amongst other things, we dropped $\Delta AS(t-1)$ without having much

effect on the estimates. Both $\Delta AS(t-1)$ and $\Delta MS(t-1)$ can also be dropped without much affecting estimates of the θ, and adding further lags in $\Delta AS(t)$ and $\Delta MS(t)$ has no substantive impact either. As before, however, including a time trend has a big effect: estimates of the θ drop noticeably, and the time trend is negative (positive) and significant for domestic (foreign) firms.

The second way that we generalized (1) is to rewrite it in a form which makes it look more obviously like a demand curve, namely

$$\log Q_j(t) = \varphi_0 + \varphi_1 \log Q(t) + \varphi_2 \log A_j(t) + \varphi_3 \log A(t) + \xi_j(t), \quad (5)$$

where $Q_j(t)$ is the output of firm j, $A_j(t)$ is it's advertising, and Q and A are total industry output and advertising respectively. (5) reduces to (1) if $\varphi_1 = 1$ and $\varphi_2 = -\varphi_3$. Judged on normal statistical grounds, these restrictions cannot be accepted when (5) is applied to domestic or to foreign firms, but the estimates of these three parameters are not terribly different from the restrictions: for domestic firms, the estimates of (5) are: $\varphi_1 = 1.03$, and $\varphi_2 = .401$ and $\varphi_3 = -.470$; for foreign firms, $\varphi_1 = .789$ and $\varphi_2 = .441$ and $\varphi_3 = -.230$. In both cases, it seems plain that market and advertising shares are positively correlated. Since (5) looks rather like a demand curve, we also included the log of the producers price index as an additional explanatory variable. For domestic firms, this recorded a statistically significant co-efficient = –3; the producer price index was not significant in the foreign output equation (which is not surprising as the index is dominated by domestic car prices and will not reflect the lower prices of many of the cars producers by foreign firms). We also included other variables (time trends, the growth of GDP, etc), all without changing the qualitative features of the results; i.e. that estimates of (5) come close to satisfying the restrictions needed to simplify it to (1).

Market and advertising shares for seven firms

Broadly speaking, the results are very similar when (1) or (2) is applied to the seven individual firms who compose these two groups. In the naive regressions based on (1), all the co-efficients on AS(t) are positive and significant; with the exception of Volkswagon, naive estimates of θ for domestic firms are much lower (.458, .543 and .532 for General

Motors, Ford and Chrysler respectively) than those for foreign firms (.964, .361, .760 and .834 for Honda, Volkswagon, Nissan and Toyota respectively). Adding in a time trend has (as before) the effect of substantially reducing the estimated co-efficient on AS(t) in all regressions. All of the trend terms are significant; those for domestic firms are negative, while those for foreign firms are positive. More interesting are estimates of log MS(t) on log AS(t) (recall that these provide estimates of the returns to scale in advertising). All of these estimates (of the parameter e identified in footnote #2) are statistically significant, and those on three of the four foreign firms are very close to unity (the co-efficient on Volkswagon is .750, a little lower than the others). The three domestic firms, however, show clear signs of diminishing returns (with co-efficients of .400, .449 and .665), something that was not evident in the aggregated regressions. The implications of diminishing returns to advertising is, of course, their advertising expenditures are less effective in generating increases in market share than much smaller level of expenditures made by foreign firms.

Since none of the four foreign firms operated throughout the period (Volkswagon was present for 32 years, Honda for 26, Nissan for 32 and Toyota for 21), there is some possibility that sample selection bias might lead us to make erroneous inferences about the size of θ. (the regressions just discussed were run only for those years when the firms were actually present in the market). We therefore reran all of these regressions (and those reported below) on the full sample (i.e. including the sample years when these firms were not operating). Although there were some differences in the estimates of θ between the full sample and the censored sample, they do not seem to be qualitatively important (θ = .51 for the full sample for Volkswagon, and .36 for the censored sample; for Honda, the estimates were 1.02 and .964; for Nissan, they were .83 and .76; and for Toyota, they were .79 and .83 respectively).

Table II shows the results when the two specifications of (2) shown on Table I are also applied individually to the seven firms (for the years that they were actually operating in the market). The analogues of regressions (i) and (iii) yield estimates of θ = .737, .231, .606, .981, - .891, .924, and .742 respectively. The two odd estimates here are Ford (neither the AS(t-1) nor the MS(t-1) co-efficient are significant) and Volkswagon (neither coefficient significant and the estimated regression displays obvious signs of mis-specification). These estimates of θ do not seem to be as closely related to the naive

estimates of θ as was the case with the estimates using more aggregated data displayed on Table I. Nonetheless, it seems clear that the disaggregated estimates have the same feature as was evident on Table I, namely that the estimated values of θ are rather lower for the three domestic firms than they are for the four firms. Further, the estimates of θ for the three domestic firms appear to fall over time, while those of (three out of four) of the foreign firms rise over time.

The regressions on Table II show estimates generated from regressions that apply the specification used in (ii) and (iv) to General Motors, Ford, Chrysler, Honda, Volkswagon, Nissan and Toyota respectively. It is clear that, as before, including the interaction time trend tends to reduce both the size and significance of the estimated co-efficient on AS(t-1). Regressions (v) – (xi) yield estimates of θ = .243 - .012*T, -.663 - .007*T, and .450 - .004*T for the three domestic firms (the Ford estimates are still rather implausible), and -.030 + .026*T, .913 - .046*T, -.190 + .028*T and .003 + .017*T (note that Nissan has an estimated value of θ < 0 for the first years of the sample, while Volkswagon's θ falls throughout the period). As before, these estimates are robust to dropping ΔAS(t-1) and/or ΔMS(t-1), or including more lagged values of each.

Advertising behaviour

Figure II shows that advertising by both domestic and foreign firms rose almost exponentially over time, and this basic pattern in evident throughout the data no matter how much one disaggregates it. Amongst other things, this means that the advertising of different firms is very highly correlated over time, and this is even true when one compares first differences between firms. The simple correlation between the advertising of domestic and foreign firms is .9860; the correlation between the first difference in domestic and foreign advertising is .5081, while that between domestic and foreign advertising intensity is .9734. Regressing domestic advertising on foreign advertising yields an estimated co-efficient = 1.68 (t = 22.02) and R^2 = .976. More interesting, a regression in first differences yields a co-efficient = .852 (t = 3.75) and R^2 = .26.

The interesting feature of the data is that advertising by domestic firms is negatively correlated with their sales -.3941. A simple regression of domestic advertising on

the sales of domestic firms for the whole sample period yields a co-efficient = -.278 (2.21) with an R^2 = .104. However, repeating the levels regressions for the period before 1974 for domestic firms yields an estimated co-efficient = .016 (2.42) with R^2 = 252. It seems, then, that there is a correlation between domestic advertising and sales, but only in the pre-1970s. After that advertising seems to rise while sales fall, and this generates a full sample correlation between the two which is less than zero. Thus, the behaviour of domestic firms changed markedly somewhere around the early 1970s, and it seems to be both possible and plausible to interpret the data from the last 20 years (or so) of the sample as corresponding to an advertising war (domestic advertising rose while sales by domestic firms fell).

For foreign firms, the pattern is rather different. The partial correlation between sales and advertising is .8156, while the a regression of advertising on sales for foreign firms over the whole period gives an estimated co-efficient = .545 (8.131) with R^2 = .665. There is some evidence that the correlation between advertising and sales is weaker before 1974 than for the period as a whole, but it is hard to be sure (most of the foreign producers did not operate on any scale before 1970, and, as a consequence, there are relatively few observations on their sales and advertising in this early period). Post-1974, foreign sales and foreign advertising rose, but the latter rose more (363% between 1974 and 1996, as compared to the 134% rise in sales over the period). The consequent increase in advertising intensity that we observe in foreign producers might be interpreted as the result of an advertising war, but it is less clear than for domestic firms.

It is very difficult to generate acceptable regressions describing the interaction between the advertising intensity (or total advertising expenditures) of domestic and foreign firms because the advertising of both sets of firms is so highly correlated. Table III shows two regressions based on (4) for domestic firms and two for foreign firms. In the first (i.e. regressions (xii) and (xiv)), lagged changes in rival's advertising are included; in the second (i.e. regression (xiii) and (xv)), lagged changes in rival's advertising intensity are included. Two features stand out. First, it appears that domestic advertising responds to foreign advertising but not the reverse, and, second, it appears that the foreign advertising equations fit relatively poorly. We experimented with several surprise terms, and generally speaking they had a larger and more significant impact in the domestic advertising than in the foreign advertising equation. They were not significant in either case however.[8] We also replicated the regressions on Table III using more lagged dependent variables, or more lagged terms in

rivals advertising. There are some signs that second and third lagged terms in domestic advertising have a bigger and more precisely determined impact on foreign advertising intensity than once lagged, suggesting that foreign firms may be rather slower than domestic firms to respond to rival's advertising. Finally, we replicated all of these regressions using total advertising rather than advertising intensity. Although this generated numerous small differences, the basic bottom line is the same: there is at least some evidence that both domestic and foreign firms respond to changes (surprise or otherwise) in their rivals advertising. Further, in the case of domestic firms, these responses clearly lead to an escalation in advertising intensity, and to a rise in total advertising notwithstanding a modest decline in sales.

Replicating the regressions shown on Table III (plus the others alluded to above) at the level of the seven individual firms that we have focussed on is complicated by the need to specify which rivals in particular each firm responds to. This creates a major problem since advertising and advertising intensity is very highly correlated across firms (none of the partial correlations of advertising or advertising intensity between the seven firms is below .80). Unsurprisingly, many of the regressions produced rather unstable co-efficients when terms in the advertising of different rival's were included, and most of them produced very low t-statistics. It is, however, the case that all seven firms responded to the advertising of one or more of their rivals, and, further, the three domestic firms appearred to respond more to the advertising of their foreign rivals than the latter did to advertising by the three big domestic market leaders.

IV. CONCLUSIONS

Our exploration of the post-War history of the US Car industry has focussed on the stylized fact displayed on Figure I, namely that the there was a very sharp escalation of advertising which occurred at the same time as industry concentration fell. To help account for this phenomena, we developed a model whose prime distinguishing feature is an equilibrium relationship between market and advertising shares. One interesting feature of this particular relationship is that it is consistent with many different equilibrium levels of advertising by firms in the market. As a consequence, it is not hard to believe that the arrival of new competitors will increase the advertising of all firms operating in the market. If, in addition, these entrants are able to seize a sizeable share of the market post-entry, then one

would expect to observe higher levels of industry advertising and lower levels of concentration as compared with the situation pre-entry. This story seems to be at least roughly consistent with the data, as Figures II and III show. There is almost no question that there exists a strong and pretty robust relationship between market shares and advertising in the data that we have examined. Further, there are fairly good reasons for thinking that the escalation of advertising we have observed in this industry was initiated by foreign firms, and the data provide some support for the view that total industry advertising rose sharply because firms departed from normal advertising decision rules and began to respond directly to previous increases in advertising by their rivals.

Just how plausible is this story? The entry dynamics that we have focussed on here are not peculiar to the US car industry. Entry has been observed to provoke an advertising war in other sectors[9], and this story is also consistent with survey evidence which suggests that the response to entry by incumbent firms (when they do, in fact, respond) is primarily by using marketing tools[10]. When this happens, it seems clear that there is no obvious reason to expect that this kind of increase in sunk costs will be associated with increases in concentration. Although it is hard to dispute the proposition that higher levels of sunk costs are likely to be associated with higher levels of concentration across industries, the results reported in this paper suggest that increases in sunk costs in a particular sector may not induce a rise in concentration in that sector over time. In particular, the particular process by which sunk costs escalate may be an important determinant of whether concentration goes up as well. [11]

There are, of course, a number of caveats about the work that we have reported which need to be registered. Most of what we have observed is more clearly discernable in aggregated data than at the individual firm level. This is probably to be expected, and our feeling is that the kind of simple models and data which we have been using do not make enough allowances for heterogeneities between firms. This is, perhaps, most apparent in the regressions which try to trace which (if any) of it's rivals each firm responds most to when choosing it's advertising expenditures. We have also made limited progress in describing the mechanics of the interdependence in advertising decisions between different firms simply because the data is so co-linear. This, of course, is consistent with the view that firms match each others advertising decisions very closely, but it does make it difficult to generate precise, reliable estimates of the relevant co-efficients. The other

caveat is that we have not been able to measure what is probably the most important feature of the relationship between advertising and market shares, namely those features of the product which induce switching by consumers. We have included time trends where appropriate to try to allow for the effect of changes in quality over time, but this is hardly satisfactory (particularly since both market and advertising shares trend over time, particularly when the data are examined at higher levels aggregation).

However imperfect, this examination of the data seems to suggest that advertising facilitates entry.[12] Certainly, it seems to be the case that foreign firms blasted their way into the US market using advertising (and perhaps by selling higher quality products). However, the story is not quite this simple, for at least two reasons. First, the opportunity for entrants to "acquire" market share disappeared as more and more entrants took advantage of it, and as incumbents responded by increasing their own advertising. As a consequence, the burst of entry facilitated by entry was of finite length – in other words, advertising provided only transitory assistance to entrants. Second, the model which we have been using to interpret the data suggests that the key to the success of entrants was probably product quality and not advertising. What induces consumer switching in this model is product quality; advertising only affects the decision of what other product to switch to. Put another way, advertising has only a short run effect on behaviour in this model: the long run demand for a particular car depends on it's quality and not on how much it is advertised.

TABLES

Fig. I: Industry Advertising Intensity and the Three Firm Concentration Ratio

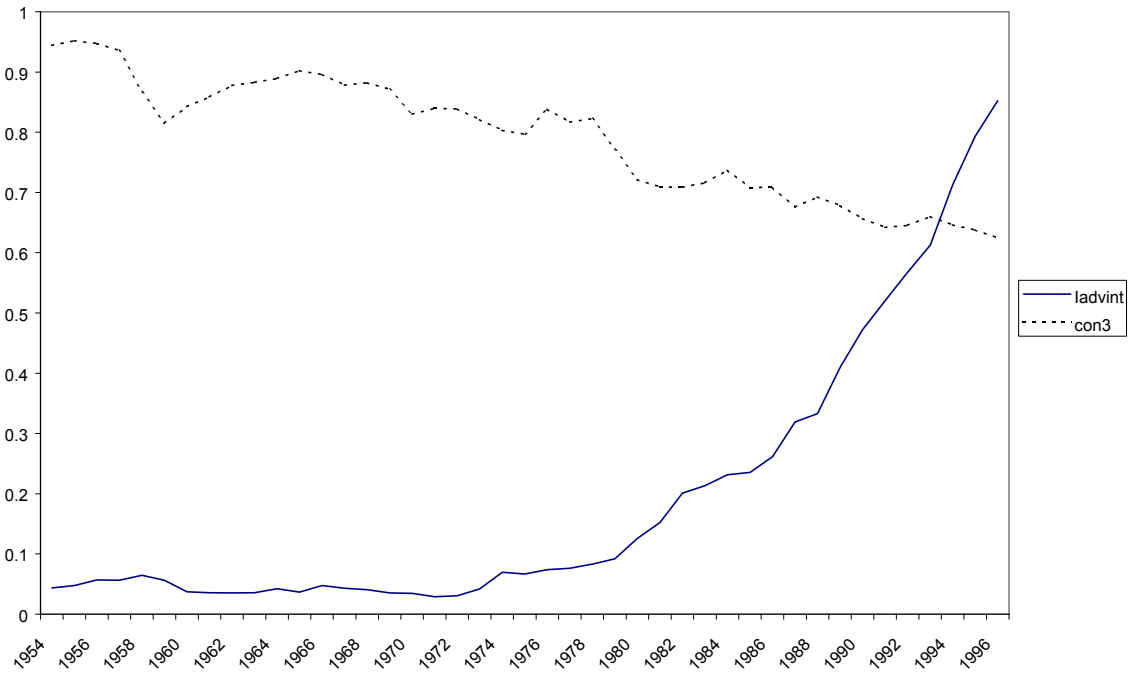


Fig. II: Domestic and Foreign Advertising Intensity

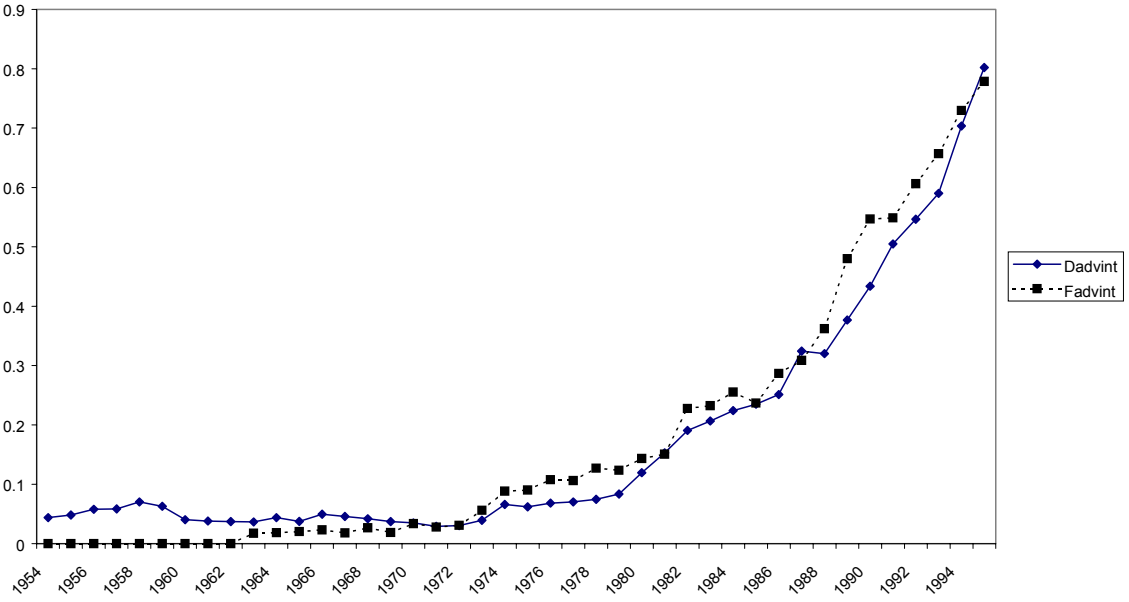
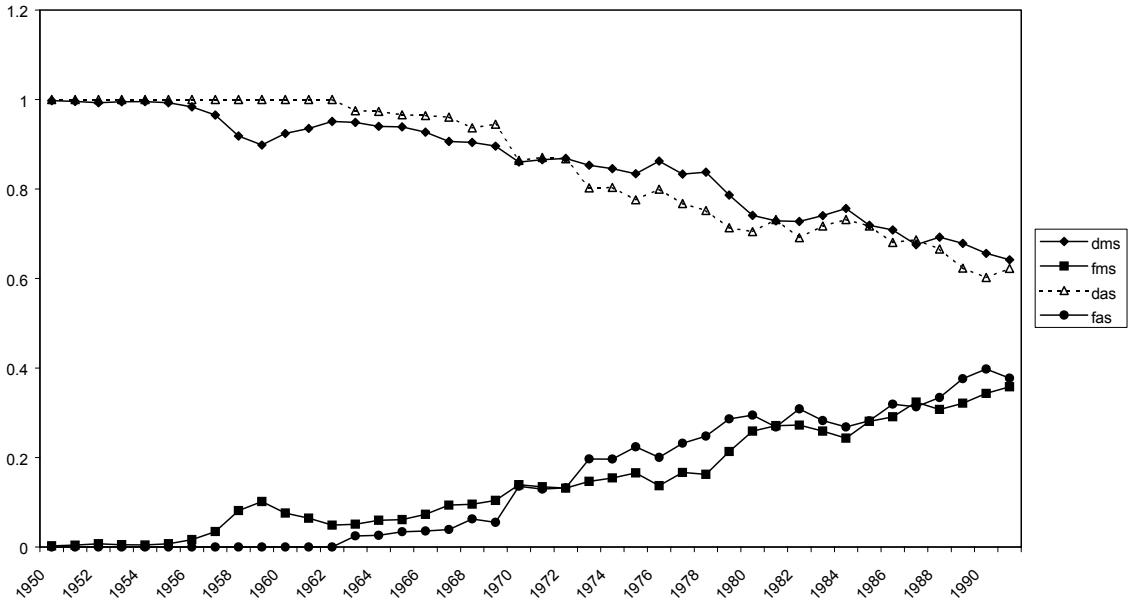


Fig. III: Foreign and Domestic Market and Advertising Shares



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NOTES

[1] Consumers might, for example, take advertising to be a signal of quality on the grounds that only high quality producers will be willing to advertise; see Nelson, 1974, or, following Sutton, 1991, it may be that advertising somehow raises consumers willingness to pay (e.g. by enhancing the product's brand image). Schmalensee, 1992. argues this kind of relationship between advertising and market shares discussed in the text is consistent with Sutton's argument that high sunk costs lead to higher levels of concentration.

[2] This model is set out in Smallwood and Conlisk, 1979, and explored further in Schmalensee, 1976 and 1978. These authors consider a slightly more general version of the model which yields an equilibrium relationship: $Q_i/Q = \lambda_{j(}A_j^e/(\Sigma\beta_j Aj^e)$, which allows for random choices by consumers (e = 0), diminishing returns to advertising (e < 1) and increasing returns (e > 1). Defining $\theta_j \equiv \lambda_j/\Sigma\lambda_j(A_j/A)^e$, it follows that $Q_j/Q = \theta_j(A_j/A)^e$.

[3] Note that if quality is taken to be exogenous, then advertising is the sole choice variable in this very simple model: prices are, by assumption, fixed and output is driven by the advertising choices of all firms at equilibrium.

[4] This is, of course, too strong. Firms will not always be taken by surprise when rivals or entrants raise/lower advertising by more than would otherwise be the case, and they may, therefore, begin to respond contemporaneously with (or even before) the surprise occurs. For simplicity, we neglect this possibility. It is worth noting, however, that this assumption does lead to a considerable simplification of the econometric model that we will ultimately be using.

[5] The data that we have used comes from the following sources: **new car sales** data for domestic firms are from annual editions of *Moody's Industrial Manual* (1954-1998) and from Wards Automotive Yearbook (1965-1998). Net sales are defined as sales minus excise taxes, sales taxes, discounts, returns and allowances. Data for the foreign firms are from Ward's Automotive Yearbook (1965-1998). Figures for domestic car sales coincide in Moody's Industrial Manual and in Ward's Automotive Yearbook; **advertising** data for the period 1954-1998 have been provided by *Ad-Age*, an agency of Crain Communications Inc. These figures are total advertising expenditures and are found in the annual list of the advertising expenses of the 100 top US advertisers studied annually by Ad-Age; and **GDP, CPI, and PPI (for motor vehicles)** data (1982=100) are from the web site of the Bureau of Labor Statistics.

[6] The other US players during the period (and their average market shares from 1954 until their year of exit) were: American Motors (3.2%, exit 1987), Hudson (.26%, exit 1958), Packard (.34%, exit 1959), Studebaker (1.36%, exit 1965), Nash (.54%, exit 1958), Willy's (.08%, exit 1956) and Kaiser (.05%, exit 1956).

[7] The rate of growth of the domestic US car market had significant positive (negative) on domestic (foreign) market shares, while the growth of total advertising and the Mitsubishi/Mazda dummy had significant negative effects. Market size and the rate of growth of GDP had (surprisingly) no significant impact on the regressions. When an advertising share/time dummy interactive variable was included, the growth of advertising and the Mitsubishi/Mazda dummy became insignificant (not surprisingly).

[8] In essence, we developed a range of models of domestic and foreign advertising (usually involving lagged dependent variables, lagged values of rivals advertising, lagged values of GDP and so on), and used these to generated "predicted" values – the Z^*_k referred to at the end of section II above. In most cases, the fits were pretty good, and the corresponding "surprise terms – the $[Z_k - Z^*_k]$ – generated positive co-efficients, but the standard errors on these estimates were always very high.

[9] For example, see Alemson, 1970, who records the impact of entry into the Australian tobacco industry, and Geroski and Murfin, 1990 and 1991, who stufy the effect of entry competition on advertising in the UK car industry. Other recent studies of the effect of advertising on entrants in particular sectors includes Leffer, 1981 and Rizzo and Zeckhauser, 1990.

[10] See Cubbin and Domberger, 1988, Smiley, 1988, and Singh et al, 1991.

[11] The main thrust of Sutton's work is on the relationship between concentration and market size, and nothing in our data is obviously inconsistent with his arguments about a lower bound to concentration in the US Car industry. Further, the nature of his argument about how endogenous sunk costs increase market concentration suggests a process by which a fragmented market creates incentives for some firms to advertise and increase their market share, particularly when market size increases (1991, pp. 48), and this too is not obviously inconsistent with our interpretation of the data. the difference is that the key actors in the US Car industry were entrants, which is, of course, why concentration – measured as the shares of the leading (i.e. domestic and incembent) players -- fell.

[12] Using a rather different approach to ours, Greuner et al, 2000, examine data on profits, sales and advertising in the US Car industry from 1970 to 1994 and argue that advertising does not impede entrant, not least because it transmits information. This paper also contains numerous references to the literature on the effects of advertising on entry barriers and previous work on the US Car industry.