Research On Effectiveness Of Agricultural Commodity Promotion

Proceedings from Seminar
Arlington, Virginia

April 9-10, 1985

Sponsored by

Farm Foundation
Agricultural Marketing Service, USDA
Economic Research Service, USDA
Foreign Agricultural Service, USDA

DISCUSSION ON ANALYTICAL, EMPIRICAL, AND MEASUREMENT ISSUES IN EVALUATING ADVERTISING PROGRAM EFFECTIVENESS

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A time series usually describes observations of a single entity — such as a market — taken at points equally spaced across time. Since it would not be possible to use monthly data to measure weekly cycles, the choice of the observation interval is considered important. Because time has no conceptual limits, the number of observations is limited only by the data collection efforts. A cross-sectional data base, which is also known as panel data or longitudinal data, describes each of many individual entities at a single point in time. Finally, a pooled data base is one which describes each of a number of entities across a sequence of time periods.

Analytical issues in evaluating advertising program effectiveness involve the construction of a statistical model based on sound economic theory. Empirical issues cover the estimation of unknown parameters in the econometric model in an optimal manner when observed data are presented. Measurement issues generally involve the proper interpretation of the estimated values in evaluating the effectiveness of advertising programs. It should be recognized that estimation and measurement are two very distinct topics. The former is a mechanical procedure once a model and the performance criteria are specified. The latter represents an attempt to attach meanings to the numerical values. The difficulties associated with the former qualify that phase of econometric modeling as an evolving science; the latter is essentially a form of art.

Elsewhere in this proceedings, Kinnucan and Grigsby present papers on the use of time series, cross-sectional, and pooled data. Together, they made a report on the state-of-the-art in econometric research of advertising effectiveness, which at present emphasizes the construction of a sales or demand function.

Analytical Issues

In short, the development of an econometric model may be based on eight considerations:

1. Constant/nonconstant variance.
2. Correlation between cross-sections/across time.
3. Correlation within cross-section.
4. Random/fixed coefficients.
5. Complete specification/multicollinearity.
6. Use of causal variables/proxies.
7. Constraints and prior information.
8. Linear/nonlinear model.

Use of generalized least squares will yield efficient estimates in the case of a heteroscedastic or serially correlated disturbance term. If correlation within cross-section exists, we may use Zellner's seemingly unrelated regression equations [19]. Most of the current econometric models on generic advertising employ fixed coefficients, although variance component models may be considered models with random coefficients. At the same time, econometricians are constantly challenged by the need for a complete specification as dictated by economic theory, and the problem of limited data and multicollinearity, which restricts the number of variables in an equation to a relative few. The resultant compromise suggests that even more care and caution should be exercised on the interpretation of numerical results. While price and income may be considered causal factors in a demand function, seasonality and advertising expenditure may be considered only proxies. There are numerous constraints in an econometric model for measuring the effectiveness of advertising. For example, a range of values for price and income elasticities are usually established as reasonable from previous studies. It is also intuitive to expect the advertising coefficient to be nonnegative; that is, advertising should not reduce sales. A statistical "linear model" refers to one which is linear in its coefficients and may have nothing to do with whether the variables involved are linear or nonlinear transformations of familiar quantities. Therefore, a log-log or a log-inverse functional form may in fact be a statistical linear model for which the least squares solutions are well-known.

A complete discussion of all these issues is impossible in one session. However, Dielman [7] has an excellent review of a number of current statistical methods for estimating multivariate relationships for each entity and for summarizing these relationships for a number of entities.

Practical Problems

As econometric models including advertising are fitted to observed sales data, a number of practical problems have been identified. Some of these problems may require simple modifications of existing theo-

ries and interpretation of results; others raise serious questions about the validity of the conclusions of several studies.

1. *Overly Precise Conclusions.* It was concluded in one report [11] that "to achieve a 2% increase in cheese sales, brand advertising would need to be increased $3.47 million." In another report [16], it was claimed that "the average return per dollar invested in media consumer advertising was $2.14." Such precise statements may be desirable to policymakers; however, they do not reflect the confidence, or the lack of it, that a researcher has in such a point estimate. If $3.47 million were raised for brand advertising, that cheese sales would indeed be increased by exactly 2% would be quite questionable. Instead, the uncertainties should be expressed in terms of a subjective or classical probability interval, which would suggest to the policymakers the relative reliability of the model under study.

2. *Inadequate/Imprecise Data.* It is ironic that the precise conclusions are usually based on extremely inadequate and imprecise data. In a typical model in which per capita sales is regressed on deflated price, per capita income, per capita advertising, price of substitute products, seasonality, and error, the population figures are usually interpolated; sales figures may be based on a small number of households in a large metropolitan area; price may be one index deflated by another index; per capita income may also be interpolated; deflated per capita advertising expenditure may not capture the impact of different media and strategies; seasonality and the disturbance term are general proxies for other factors that have not been included in the model. In subsequent analyses of projected sales and producer returns, some researchers simply ignore the existence of the stochastic error term. Moreover, given the many variables that should be specified in a model, there may only be forty to fifty data points. Limited data present a severe constraint on the researcher to arrive at meaningful and reliable conclusions, to the extent that such conclusions may not even be possible.

In this regard, the researcher should identify the data requirements and demonstrate the uncertainty in his conclusions in terms of an interval estimate. Industry and government should share the responsibility of creating and maintaining reliable time series, cross-sectional, and pooled data bases, if meaningful results are to be derived.

3. *Mathematical Errors.* The familiar log-log functional form for a demand function may be expressed as:

$$Sales = (Advertising^{**}b) * f$$

where ** will represent exponentiation, * multiplication, and f is a function containing all other variables and the error term in a multiplicative manner. When b is nonnegative, the model suggests diminishing return on sales with respect to advertising. However, the model also suggests that there would be no sales if there were no expenditures on advertising. Since there was no generic advertising for many

agricultural commodities for many years until recently, this assumption is obviously faulty and will tend to overstate the effectiveness of advertising. This fact was discussed three years ago by Kesecker and Wu [9], but many researchers today still fail to recognize its importance and implications.

As logarithms are taken on both sides of the equation, the model may be expressed as:

$$log(Sales) = b * log(Advertising) + log(f)$$

A mathematical problem appears when advertising expenditure is zero since *log(0)* is an extremely small value that is undefined. Various attempts to portray *log(0)* as a finite number are arbitrary and simply incorrect, and some have resulted in grossly misleading interpretations.

We propose a simple modification where *log(d + Advertising)* is considered instead. The value *d* or *d**b* should logically be positive and may represent the baseline sales level when no advertising is present. Although it may be a specified value, we prefer to consider *d* an unknown parameter to be estimated in a nonlinear model setting. The same problem exists in a log-inverse functional form for which an alternative consideration may be:

$$1 / (d + Advertising)$$

where *d* remains to be estimated.

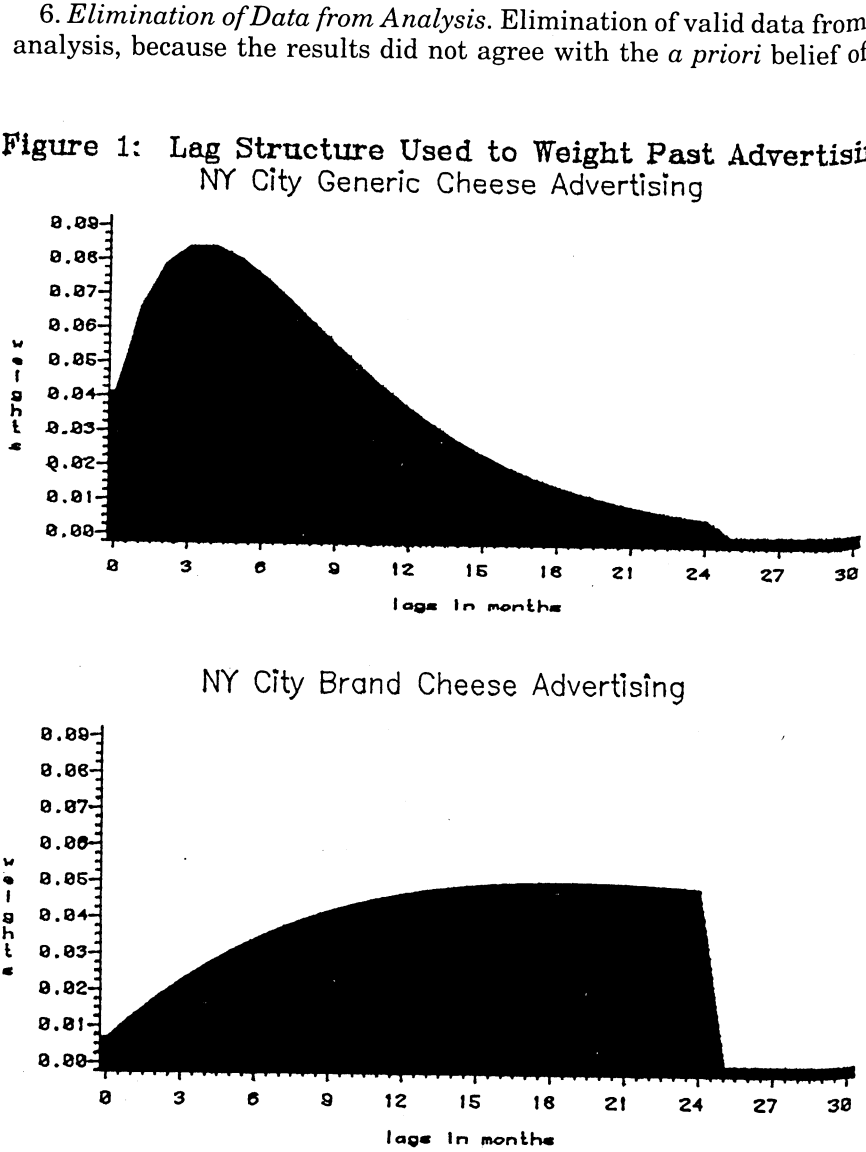
4. *Results Cannot Be Duplicated.* For statistical linear models, the *F* value may be expressed as a simple function of *R* square, the number of parameters and the number of observations. Occasionally, the equation may not be satisfied by published results. In other cases, regression results may not be duplicable. Failure to duplicate does not necessarily diminish the value of published results, but it does cast some doubt on the validity of the conclusions. It was during verification exercises that the mathematical error of assigning values to *log(0)* was discovered.

5. *Unexplained/Unreasonable Results.* The use of trigonometric variables with harmonic frequencies initially requires the same degree of freedom as the use of monthly dummy variables in describing seasonality. If the underlying pattern is primarily cyclical, the sine and cosine decomposition, as proposed by Kinnucan elsewhere in this proceedings, indeed may reduce the number of parameters. This is a simple form of Fourier analysis [3] which presumes the existence of periodic components. However, generalization of this situation to all seasonable patterns may be erroneous, especially when only a few months during the year may have spike effects, in which case the dummy variable approach will become superior. The use of trigonometric terms or dummy variables appears to be a secondary issue; the appeal of the fitted pattern to intuition, which remains to be explained, may be more meaningful.

In Figure 1, the lag structures [11] used to weight generic and brand advertising of cheese in the New York area are depicted. In the generic case, the peak of a Pascal distribution is reached at lags of three and four months, and the weights deteriorate steadily for almost two years. Such a distributed lag structure may in fact be plausible. However, when a similar 24-month lag was assumed in the brand case, the weights beyond two years abruptly became zero. When this lag structure is applied, the conclusions are at least suspect.

6. *Elimination of Data from Analysis.* Elimination of valid data from analysis, because the results did not agree with the *a priori* belief of

Figure 1: Lag Structure Used to Weight Past Advertising



the researchers, is perhaps the most damaging action one can take in the field of econometrics. This topic probably does not deserve further discussion.

Conceptual Problems

In addition to the practical problems that we have experienced, a number of conceptual problems are also disturbing. They are presented to stimulate further discussion among researchers in this field.

1. *What is the model performance criterion?* Many disagreements have arisen among econometricians as to the merits of the various modeling techniques. However, if decisions are to be made for the future based on historical data, there is one standard by which every approach may be measured: any model, regardless of how it is derived, should continue to adequately describe or represent data realized subsequent to the estimation process.

Forecasting is like driving a car forward by looking at only the rear view mirror. It is a difficult task. On the other hand, if there is no confidence in the ability of the model to generate accurate forecasts, why should the policymakers place any confidence on the interpretations and recommendations derived from the model?

At present, the performance of an econometric model is based primarily on its goodness of fit to observed data and its appeal to intuition and theory. In addition, a validation period may be established in advance, as part of the design of an organized study. This is perhaps a necessary criterion for all econometric studies of advertising effectiveness.

2. *Should advertising be isolated as a causal factor?* An econometrician will always recognize the need to specify as many of the number of relevant economic factors as possible to be included in a model, but at the same time, that number is limited by both the amount of data and the potential collinearity between some of the factors. As some factors are included but others are ignored, the reasons motivating these selections should be closely examined.

There appears to be a need to identify a minimum number of economic factors to be included in a demand function; the data requirements may then be specified by the researchers. The impact of ignoring meaningful exogenous variables on the measurement of advertising effectiveness is unknown.

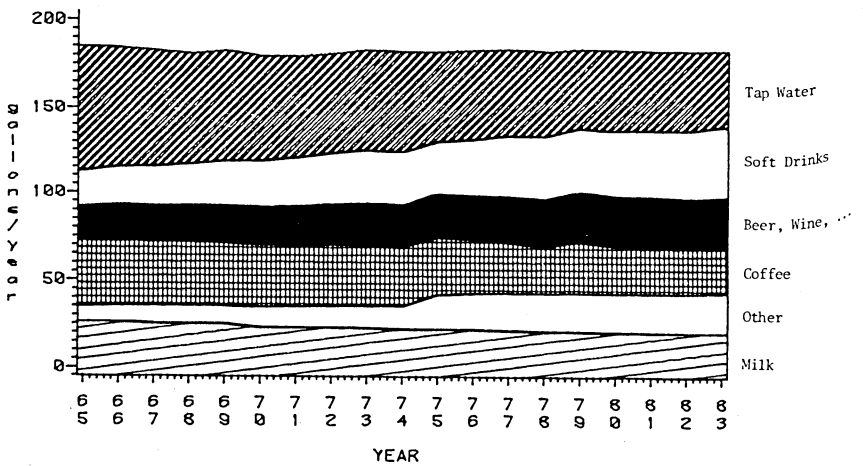
3. *Should an advertising dollar be translated into a uniform sales effect?* The use of total advertising expenditure as a proxy for program effectiveness is, as Grigsby suggests elsewhere in this proceedings, quite questionable. The amount of exposure and audience differ between magazine, radio, television, and other media. Strategies, of which some may be difficult to even quantify, may change during a given

time period. Examples include the timing of broadcasts or the appeal of new slogans.

Options on this topic are limited. A logical approach is to keep detailed records of expenditures for each medium and the times when there were significant change in advertising strategies. The additional parameters included in the model may be offset by additional observations on sales, either across sections, across time, or both.

4. *What are the causes of consumption decline? What is the demand?* It appears that current econometric research addresses neither the causes of consumption decline nor the actual consumer demand of agricultural products. Although price and income have been considered, their impact has been measured as minimal. Lower prices and higher income generally have not appeared to have stimulated significantly higher sales of agricultural products, as one might expect. More recently, advertising has been injected in an attempt to increase demand. However, demand for eggs and fluid milk has experienced a long steady decline in the last fifteen years which may not be satisfactorily explained by lack of advertising. During this period, health concerns and advertising for soft drinks and beer are undoubtedly a strong form of negative advertising for eggs and milk. New products such as powdered drinks may have added competition in the beverage market. Since the capacity of an individual to consume is limited, increased consumption of soft drinks and beer in the last two decades has apparently been at the expense of milk and coffee (Figure 2). In general, as Meinhold and Wu [14] concluded, simultaneous generic

Figure 2: Annual Per Capita Consumption of Beverages



Other=Tea,Juices,Bottled Water,Powdered Drinks
Source: Beverage Industry, 2/84

advertising should have a nullifying effect; increased consumption of one commodity must result in decreased use of another. Current econometric research is commodity-specific; the potential trade-off effects between commodities have not been fully considered.

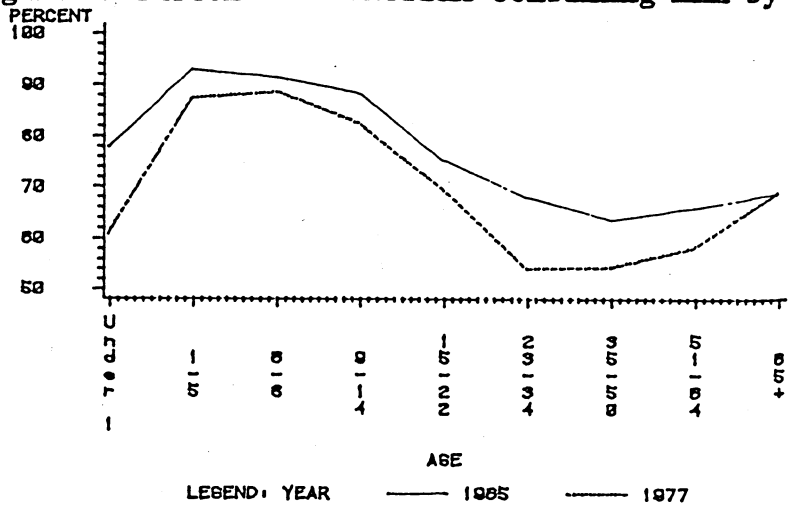
Another important cause of consumption decline that has been overlooked is the change in our demographic composition; research literature such as [10] which may be cited is scarce. Bunch [5] reported that fewer people are drinking milk, and those who do so are drinking less. When the statistics are reported by age group as in Figure 3, it becomes apparent that the drop in percentage of individuals drinking milk is almost uniform since 1965, with the biggest drops in the very young (under one year old) and the 23-64 age group. Among those who drink milk, the drop in consumption amount is also uniform across age groups. As age increases, the magnitude of the drop decreases monotonically. The milk industry has the older generation of our nation to thank because they have remained the only group who have not reduced their consumption.

The milk consumption pattern of the aging "baby boom" generation has apparently caused the decline in demand. A bigger concern appears to be those who were very young in 1977. Only 61% of them consumed milk, which was 17% lower than their counterparts in 1965. Those who drank milk in 1977 consumed 12 ounces a day, which was significantly less than the 21 ounces a day their counterparts consumed twelve years earlier. Change in consumption patterns in this group and those who were born later obviously will impact our consumption patterns for a long time to come. Other major differences based on sex and ethnic groups were also reported by Bunch [5].

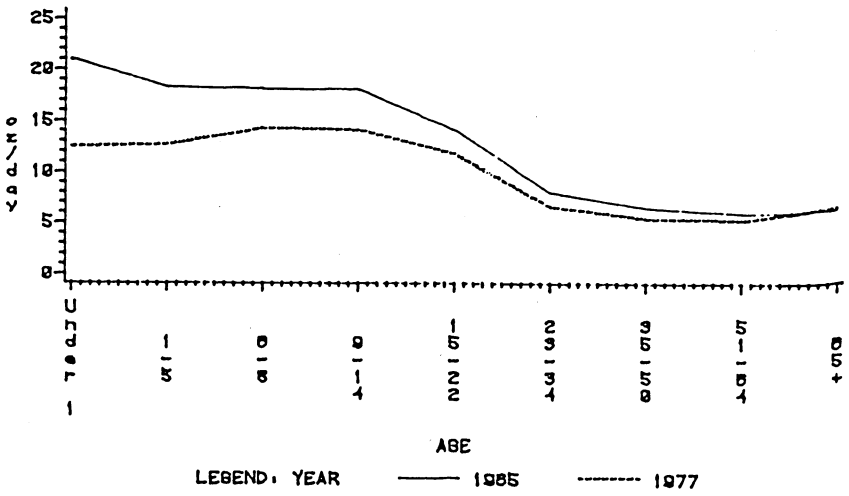
As our population changes, how has the consumer demand of the product changed? An indication in the case of fluid milk may be found in Figure 4. Lowfat and skim milk, which made up only 9% of per capita sales of fluid milk in 1960, increased to 42% in 1983. Had the industry not responded to the increasing demand of lowfat and skim milk, the results would probably have been disastrous to the industry and no amount of advertising would likely have been able to salvage the situation.

5. *Are the estimates of advertising effectiveness conservative?* Kinnucan claims in this proceedings that estimates of advertising effectiveness are unambiguously conservative in the sense that they are understated. We disagree with this assessment for three reasons. First, significant factors have been omitted. Second, the generalization was made after only one or two empirical studies that may not be conclusive. Finally, the theoretical result quoted from Maddala [12] is a simplified limiting result; that is, the number of observations is required to be very large. In the case of generic advertising, researchers continuously complain about insufficient data, which contradicts the fundamental requirement of this theoretical result.

Figure 3: Percent of Individuals Consuming Milk by A



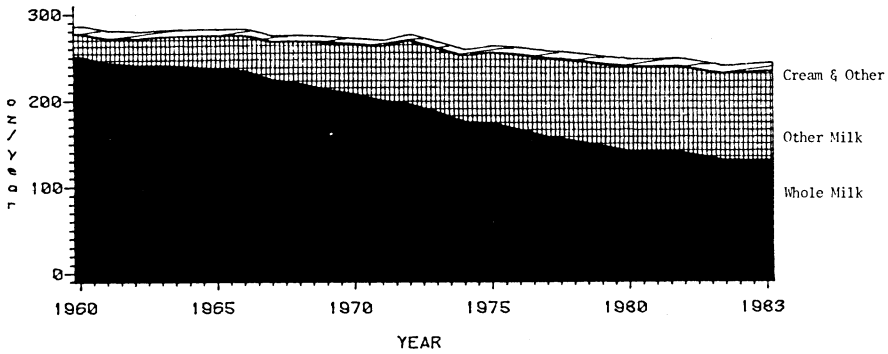
Per Capita Annual Consumption of Milk by Ag



Source: USDA, Economic Research Service

The improper log-log or log-inverse functional form actually suggests that the estimates of advertising effectiveness may in fact be overstated.

Figure 4: Per Capita Sales of Fluid Milk Products



Other Milk=Lowfat, Skim, Flavored, & Butter Milk
Cream & Other=Yogurt, Half & Half, Eggnog, Light, Heavy, and Sour Cream
Source: USDA, Economic Research Service

Summary

Kinnucan and Grigsby have presented a description of current econometric methods in measuring advertising effectiveness. The many existing practical and conceptual problems encountered when these methods are applied should not be taken as a signal that research should be discontinued in this area; quite the contrary, problems in general appear correctable and we hope that they will stimulate new, responsible, and exciting investigation.

Other statistical methodologies remain to be explored. Fourier analysis has been successful in modeling seasonality in one case; the Box-Jenkins techniques [4] may be appropriate in some other case studies. Bayesian methods appear to be suited for application because of the various prior constraints [1]. West, Harrison, and Migon [18] recently developed dynamic Bayesian models for application in nonlinear, non-normal time series and regression problems. An expository article on the Kalman Filter was presented by Meinhold and Singpurwalla [13]. The development of the Expectation-Maximization (EM) algorithm by Dempster, Laird and Rubin [6] has led to Shumway and Stoffer's [15] estimation of prior parameters which was a considerable problem in earlier attempts in modeling generic advertising [17]. An application of the Kalman Filter in agricultural economics may be found in [8].

Technically correct statements are essential in our econometric study of generic advertising; technically incorrect statements, if overlooked

and misinterpreted, may inflict permanent damage to the field of econometrics.

Sound econometric research can be conducted only when there are sufficient and reliable data. The researchers share the responsibility with the industry in identifying their data requirements; government and industry share the responsibility in providing them. We recommend a validation period when econometric models may be tested independently; a measure of performance for the models should then be derived. In addition, one should be able to duplicate published econometric results if all reported procedures are followed.

When an advertising program may be considered effective remains to be defined, and there may in fact be many different definitions depending on the commodity. However, without a proper definition, disagreements will persist. Increased sales is presently an ad hoc criterion adopted by researchers, but industry and government should share the responsibility of providing the proper definition(s).

Given the many unknown factors, it is impossible for a policymaker to intelligently place confidence in a point estimate. In addition, the researcher has a certain degree of uncertainty in his results. For these two reasons, it is recommended that an interval estimate, generated either objectively or subjectively, should be reported.

Measurement of advertising effectiveness is quite different from estimation of unknown parameters in an econometric model. When the underlying model is incorrect, estimates may still be generated, but the interpretations based on these estimates may be misleading and erroneous. Therefore, before one can actually make conclusions about the effectiveness of advertising, the econometric model must be supported by sound economic theory and the estimates must be generated according to acceptable criteria and within reasonable limits.

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