Factors Affecting the Demand for Cigarettes

By S. M. Sackrin

Few commodities exhibit as strong a trend factor as do cigarettes. The phenomenal rise in popularity in this form of smoking since the early 1920's is well known, but to the analyst seeking to identify factors affecting demand for cigarettes, the strong trend factor which tends to overshadow the effects of other determining influences frequently is a vexing and frustrating obstacle. This article reports the results of statistical analyses of factors affecting the demand for cigarettes. Particular attention is given to alternative methods of handling time as a variable, and to the assumptions regarding the shape of the time trend implicit in each. The author acknowledges the helpful suggestions of Arthur G. Conover and Anthony S. Rojko of the Economic Research Service.

AS ANYONE can plainly observe, cigarette smoking is the dominant form of tobacco consumption in the United States, but this was not always the case. In 1920, for example, consumption of cigarettes was exceeded by that of cigars and far exceeded by the combined total of smoking tobacco, chewing tobacco, and snuff. In the 40 years or so since then, however, the growth in consumption of cigarettes, with but two notable exceptions, was uninterrupted. From a total of about 45 billion (611 per person, 15 years and over) in 1920, consumption of U.S. smokers grew to 503 billion (3,989 per person) in 1961. The tobacco consumed in cigarettes in 1961 accounted for 83 percent of all tobacco consumed in the United States.

The extraordinary growth in consumption of cigarettes has posed a problem in analyzing the factors affecting demand. At best, the disentangling of the separate effects of a number of explanatory variables is always fraught with some peril. The task of correctly assessing the influence of each is rendered more difficult by the existence of a strong time trend which may tend to overshadow the effects of other determining factors or which may have a common influence on both the dependent and independent variables. There are several ways for handling trend in statistical formulations. For example, the transformation to first differences allows for the presence of a strong time trend. But the use of a certain formulation implies a specific shape of the time trend. The question then becomes: Is the shape of the time trend implied by the formulation selected a correct representation of trend? In the course of this article, alternative statistical formulations used in the measurement of trend will be discussed, and results from analyses of factors affecting cigarette consumption used to illustrate principles involved.

Variables Considered

In most demand studies, price and disposable income are almost invariably included as factors influencing consumption of a commodity. In addition to price and income, however, there are other factors that affect consumption of cigarettes. The 1955 smoking-income survey (*6*)* showed that there are marked differences between the sexes insofar as cigarette consumption is concerned; daily consumption of women smokers on the average is around one-third less than that of male smokers. Both among men and women smokers, age differences affect consumption; heaviest consumption occurs among those 25–54 years of age. Cigarette consumption of those living off farms (urban and rural nonfarm) tends to average from 8 to 10 percent higher than that of smokers on farms. Regional differences in rates of smoking were also noted, but these basically reflect the urban-rural composition of the population in each region.

Normally, cigarette smokers are characterized by a high degree of product loyalty. Virtually all women smokers are, of course, smokers of cigarettes. But even in the case of male cigarette smokers, over 60 percent smoke cigarettes exclu-

*Italic numbers in parentheses refer to Literature Cited, page 88.

sively, according to the 1955 survey, and an additional 30 percent smoke cigarettes regularly, with an occasional cigar or pipe.

With smoking preference indicated so clearly, product substitution among cigarette smokers, barring extreme price changes, is not very likely. About the only time when there appeared to be a large-scale and fairly sustained shift from cigarettes was during the depression 1930's, particularly 1931 and 1932, when consumption of ready-made cigarettes declined, whereas that of smoking tobacco for pipes and roll-your-own cigarettes increased. But this was an extraordinary period of widespread unemployment and reduced consumer income.

Although in subsequent periods of economic recession there has been a tendency for smoking tobacco consumption to increase, these gains have usually been temporary and do not appear to have affected cigarette consumption appreciably. Because of the limited substitution for cigarettes, there does not appear to be need for introducing the price of competitive items as additional explanatory variables. As a matter of fact, when the retail price of smoking tobacco was explicitly introduced as a variable in preliminary statistical analyses, its regression coefficient was in all cases statistically nonsignificant.

Since World War II, two major developments have affected cigarette consumption. First of these has been the publicity concerning the effects of cigarette smoking on health. The successive declines in consumption in 1953 and 1954 were at least partly due to the publicity linking cigarette smoking with lung cancer. The steady growth in cigarette consumption which had been underway since the setback of the depression 1930's was interrupted, and it was 3 years before aggregate domestic consumption returned to approximately the same level as before the "health scare."

The other important development since World War II has been growth in production of filter-tip cigarettes. In 1952, at the start of the publicity concerning cigarette smoking and health, filter-tip cigarettes comprised only 1 percent of total output. In the following 7 years, this proportion grew steadily and by 1959, nearly half of all cigarettes produced were filter-tipped. Last year, the proportion increased to over half. The popularity of filter-tips undoubtedly contributed to the resumption in the upward trend in cigarette consumption. Apparently, many smokers regard them as an answer to the "health problem" and filter-tip cigarettes have a special appeal to women and younger smokers. Of some importance also is the fact that there appears to have been a tendency for those who switched to filter-tip cigarettes to consume more than they did when they smoked nonfilter cigarettes.

In summary, the factors considered for analyzing cigarette consumption were price, disposable income, the sex ratio of the population (15 years and over), the age composition of the population (15 years and over), the farm-nonfarm composition of the population (15 years and over), and, in the postwar period particularly, the effects of the "health scare" and the enormous growth in popularity of filter-tip cigarettes.

All of these factors, however, were not included in the statistical analysis. The ratio of females to males, 15 years and over, has increased almost steadily from 97 per 100 males in 1926 to about 105 per 100 males in 1958. But what is of greater importance than the overall sex ratio is the ratio of women smokers to men cigarette smokers. These data are not available except for scattered individual years. Such evidence as is available does indicate that the proportion of women smoking cigarettes has increased markedly since the 1920's. This has contributed to rising cigarette consumption, but the addition to consumption has not been as great as it would have been if the average smoking rate among women equaled that of men.

There has been remarkable stability in the proportion of males and females aged 25–54. Considering the numbers of persons in those age brackets as a percentage of all persons 15 years and over, the percentage varies only between 56 and 57 throughout the entire period 1926–58. On the other hand, in the same period there was an increase in the proportion of nonfarm persons among those of smoking age, rising from about 74 percent in 1926 to about 88 percent in 1958. This change, however, was gradual. Year-to-year changes were so slight as to make it unfeasible to introduce this variable explicitly in any first-difference analysis. And in a preliminary analysis based on actual data, the regression coefficient was not statistically significant although its sign was in accordance with expectations.

The effect of the "health scare" on cigarette consumption was most apparent in 1953 and 1954, but judging from the resumed uptrend in consumption, has been of considerably less importance since that time. Thus the two "abnormal" years can be omitted from the period used for statistical analysis.

Of the factors enumerated above, those that remained for inclusion in statistical analysis were price, income, and filter-tip cigarettes as a proportion of total cigarette consumption. The proportion of filter-tip cigarettes was not introduced explicitly as a variable, but its effect was represented by a shift variable which took on a zero value for pre-World War II years and a value of one for postwar years. To these was added a time trend, to allow for those factors which could not be introduced explicitly into the equation. These would be changes occurring gradually and affecting cigarette consumption, such as changes in taste and fashions in smoking; the growing percentage of smokers among women, and to a lesser extent, among teenagers; and the growing urbanization of the population.

As already indicated, the price of smoking tobacco was dropped as a variable, on the basis of results from preliminary analyses. Normally, the price of smoking tobacco has little effect on cigarette consumption. Unlike more usual cases of competing products, consumers do not keep the respective price of cigarettes and smoking tobacco under surveillance to decide which is the better "buy." Thus, normally, changes in prices of smoking tobacco do not by themselves win additional smokers or deter confirmed smokers.

Statistical Analysis

A series of least-squares regression analyses was made, utilizing the following variables:

Q_t—annual per capita taxable consumption of cigarettes, population 15 years and over, in continental U.S. (packs of 20 cigarettes)

P_r—average U.S. retail price, deflated by BLS Consumer Price Index (cents per pack)

Y—per capita disposable income, deflated by Consumer Price Index (thousand dollars)

T—time (1926=1)

D—shift variable, taking on a zero value for prewar years and a value of one for postwar years

Q_{t-1}—per capita taxable consumption of cigarettes, population 15 years and over, in continental U.S., lagged one year (packs of 20 cigarettes)

The period examined was 1926–58, omitting the war years 1942–45 and also 1953 and 1954. Both price and per capita income were deflated to put them in "real" terms, although there may be some conceptual differences of opinion concerning the advisability of deflating price.[1]

Per capita consumption in continental United States omits consumption by Armed Forces overseas. The former variable was used instead of per capita consumption of all United States smokers, including Armed Forces overseas, as interest partly centers on consumption as affected by price. The price to members of the Armed Forces overseas is considerably cheaper than the mainland price as the Federal excise and State taxes are not included. Hence the consumption variable used reflects changes in the retail price most typically confronting consumers at time of purchase.

As the BLS series on retail prices during the period under review was not considered to be completely representative because it priced only standard brands and did not fully reflect taxes in all States, a retail price series was constructed from data on manufacturers' list prices of the different kinds of cigarettes, State tax revenue, and available data on distribution markups.

In statistical analysis of demand, frequently the data are expressed in first differences to overcome the influence of trend, to reduce intercorrelation between explanatory variables, and to reduce serial correlation of residuals. In an analysis run in first differences of logarithms, per capita consumption of cigarettes was related to real price and real disposable income per capita. The following regression equation and statistical coefficients

[1] Tennant (*10*, p. 124 f.) preferred to use undeflated prices, arguing that deflation would introduce correlation between consumption and prices, even if none existed. According to this view "a deflated price is a function of the general price level, which in turn is a function of the national income." As tobacco consumption is correlated with income, it follows, according to Tennant, that it is also some function of deflated price.

were obtained. Numbers in parentheses beneath the regression coefficients are their respective standard errors.

$$\Delta \log Q_t = 0.0146 - \underset{(0.10)}{0.56}\ \Delta \log P_r + \underset{(0.07)}{0.45}\ \Delta \log Y \qquad R^2 = 0.84 \quad (1)$$

The constant term is a measure of residual trend, as it implies that even if there were no change in the explanatory variables, per capita consumption of cigarettes would increase by 3.4 percent a year. (The antilog of 0.0146 is 1.034.) When calculated values were computed, however, residuals for most prewar years were positive, whereas those for most postwar years were negative. The reason was attributed to a faulty representation of trend. This prompted a closer examination of the shape of the time trend implicit in a first differences of logarithms analysis.

Differences in Shape of Time Trend

Many analysts may not be aware of the fact that there is a fundamental difference between the shape of the time trend depending on whether (1) the logarithm of time ($\log t$) is used as an explicit variable, or (2) first differences of logarithms are used, and the constant term or "a" value (if statistically different from zero) taken as a measure of trend.[2] This is in contrast to the situation where the data are expressed in original form. In the latter case, it makes no difference in the shape of the time trend if original variables or first differences are used; the coeffcient on t or the constant term in a first difference analysis both yield a linear trend.

When first differences of logarithms are used, the constant term or the residual trend coefficient obtained from such analysis is of the exponential type, that is to say, of the form c^t. On the other hand, use of log of time as a variable is equivalent to a power function. As pointed out by Foote (*3*, p. 40) the logarithmic expression of the exponential function would be ($\log c$) t. By this function, as t increases, we raise c (a constant) to a progressively larger power. The resulting curve is one that is concave upward, that is, the increase expressed in actual units grows progressively larger with time. (See fig. 1.) This arises because effect we apply a constant percentage increase to a progressively larger number, which results in progressively larger increments or an acceleration in the growth curve. Such a representation of trend is clearly inappropriate for those cases—probably the majority—where growth is rapid at first but tends to flatten out with the passing of time.

Such a trend can be obtained by introducing time explicity as a variable, and expressed in logarithmic form. This would be a curve of the type t^c or $c \log t$. A preliminary analysis of cigarette consumption which used the log of time as a variable yielded as one of the parameters 0.2627 log t. When the coefficient is positive but less than unity, as in this case, we get a growth curve that rises steeply at first but then flattens out. (See fig. 1.)

In order to avoid an exponential time trend, the first analysis was rerun, introducing the logarithm of time as an explicit variable. But, since the "a" value or constant term in a first differences analysis also reflects trend, it must be eliminated to avoid duplication. To center the effect of trend on the coefficient representing time, *unadjusted moments* were used.[3] The following equation and statistical coefficients were obtained:

$$\Delta \log Q_t = -\underset{(0.13)}{0.43}\ \Delta \log P_r + \underset{(0.08)}{0.53}\ \Delta \log Y + \underset{(0.03)}{0.15}\ \Delta \log T \qquad R^2 = 0.82 \quad (2)$$

Residuals computed from this analysis were more randomly distributed than when the trend representation was the exponential curve. The Durbin-Watson test for serial correlation in the residuals was inconclusive.

Additional Statistical Analyses

To take account of the effect of filter-tip cigarettes on consumption, an analysis was run relating per capita cigarette consumption to real price, real disposable income per capita, time, and

[2] The problems relating to the use of time as a variable, and alternative power and exponential functions, are discussed by Foote (*3*, pp. 39–43).

[3] The use of unadjusted moments when working with first differences is mentioned by Foote (*2*, p. 3). In the present case, the use of unadjusted moments to eliminate the "a" value or constant term in effect assumes it to be zero.

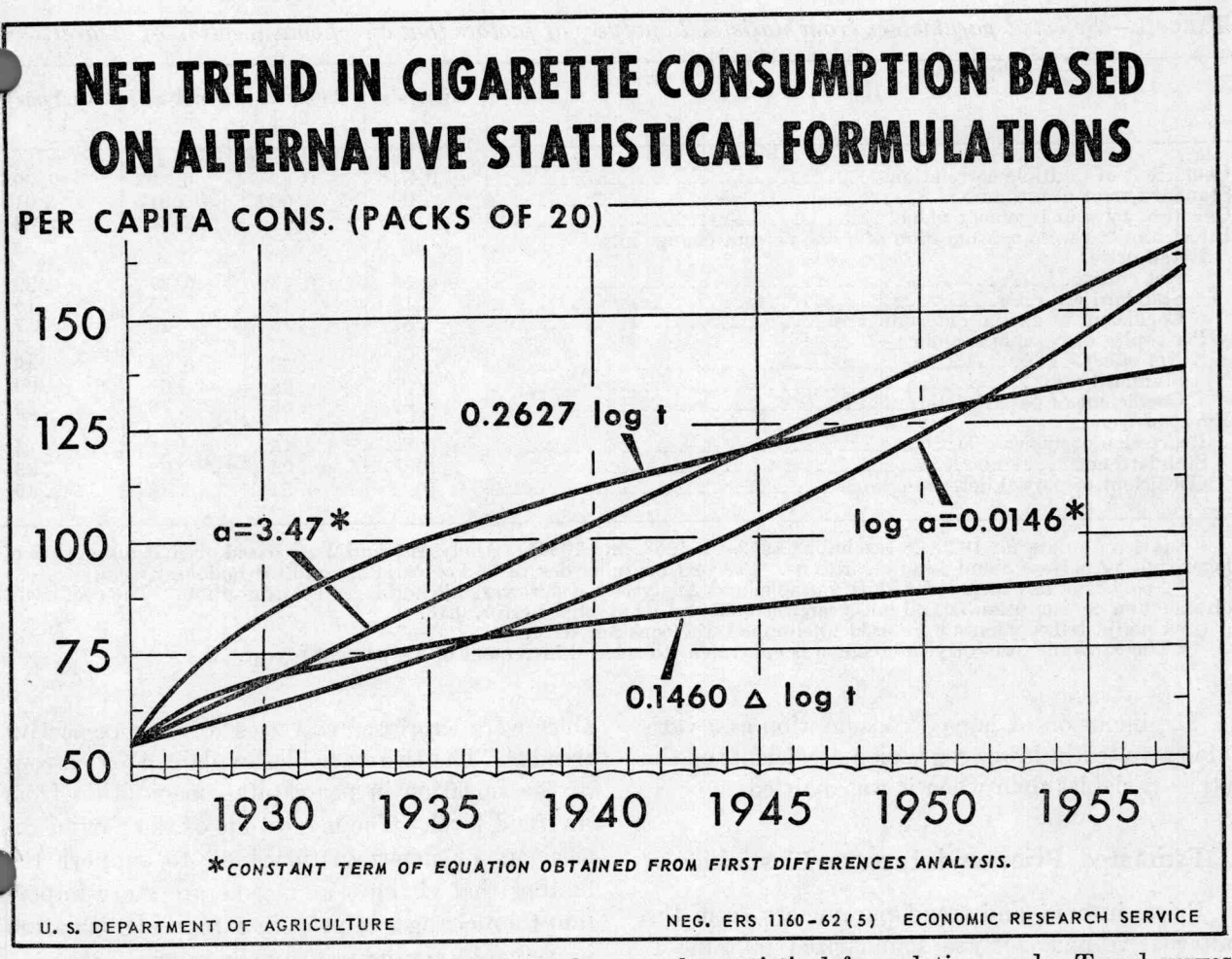

Figure 1.—The shape of the time trend depends upon the statistical formulation used. Trend curves shown here include linear trend, two power functions, and an exponential function. Regression coefficients on other variables are affected by the type of curve selected to represent trend.

a shift variable (D), which took on a value of zero for prewar years and 1 for postwar years. Original data in logarithms rather than first differences were used, because of inclusion of the shift variable. As all data were expressed in logarithms, the time trend implied by this formulation was the power function, deemed appropriate in the case of cigarette consumption. The following regression equation and statistical coefficients were obtained:

$$\begin{aligned}\text{Log } Q_t = 2.2160 &- \underset{(0.15)}{0.37} \log P_r + \underset{(0.07)}{0.64} \log Y \\ &+ \underset{(0.02)}{0.21} \log T + \underset{(0.02)}{0.09} \log D \qquad R^2 = 0.993 \quad (3)\end{aligned}$$

Another statistical analysis was made, utilizing the same variables as the foregoing but adding consumption lagged one year (Q_{t-1}) as an additional variable, since consumption in any given year is partly determined by consumption in the preceding year. This appears to be particularly applicable to cigarettes, a commodity characterized by habitual use. The following regression equation and statistical coefficients were obtained:

$$\begin{aligned}\text{Log } Q_t = 1.5283 &- \underset{(0.14)}{0.29} \log P_r + \underset{(0.09)}{0.48} \log Y \\ &+ \underset{(0.03)}{0.14} \log T + \underset{(0.03)}{0.04} \log D + \underset{(0.13)}{0.35} \log Q_{t-1} \\ &R^2 = 0.995 \quad (4)\end{aligned}$$

Note: The regression coefficient on the shift variable D is not statistically significant at the 5 percent level of probability. The Durbin-Watson test for serial correlation in the residuals was inconclusive.

TABLE 1.—*Selected parameters from statistical analyses of factors that affect consumption of cigarettes* [1]

Item	Analysis 1	Analysis 2	Analysis 3 [2]	Analysis 4 [2]
Coefficient of multiple correlation	0. 84	0. 82	0. 993	0. 995
Standard error of estimate	. 009	. 002	. 017	. 015
Constant term or intercept value	0. 015	([3])	2. 22	1. 53
Effect on per capita consumption of a one percent change in:				
Retail price:				
Net effect	−0. 56	−0. 43	−0. 37	−0. 29
Standard error	. 10	. 13	. 15	. 14
Coefficient of partial determination	. 57	. 34	. 20	. 17
Per capita disposable income:				
Net effect	. 45	. 53	0. 64	. 48
Standard error	. 07	. 08	. 07	. 09
Coefficient of partial determination	. 67	. 65	. 78	. 59
Effect of trend:				
Regression coefficient	([4])	. 15	. 21	. 14
Standard error	([4])	. 03	. 02	. 03
Coefficient of partial determination	([4])	. 54	. 84	. 46

[1] Based on data for 1926–58 (excluding 1942–45, 1953, and 1954). Analyses 1 and 2 are based on first differences of logarithms; Analyses 3 and 4, on logarithms. See text for fuller description of variables and methodology used.

[2] Analysis 3 also included a shift variable, and Analysis 4, a shift variable and lagged consumption. The coefficient obtained on consumption lagged one year was 0.35 and its standard error, 0.13.

[3] Unadjusted moments were used to eliminate the constant term.

[4] The constant term or y-intercept was equivalent to a trend increment of 3.4 percent a year.

The inclusion of lagged consumption as a variable resulted in lower regression coefficients on the other variables than when it was omitted.

Estimated Price and Income Elasticities

Price, income, and trend parameters from the alternative analyses are summarized in table 1, together with partial coefficients of determination. Results from Analyses 2–4 probably are more acceptable as they represent the effect of trend by a power function. Results from these analyses suggest that the price elasticity of demand for cigarettes is between −0.3 and −0.4, and the income elasticity of demand, about 0.5. Changes in real disposable income appear to be more influential than changes in real price in affecting cigarette consumption. The relative importance of trend is not as clear-cut. However, the reduction in the coefficient of partial determination of 0.84 in Analysis 3 to 0.46 in Analysis 4 is undoubtedly due to the inclusion of Q_{t-1} as a variable in the latter; the effect of trend is thus divided between the explicit time variable and lagged consumption.

Additional evidence of the greater influence of income than price on cigarette consumption was obtained from another analysis. In order to overcome the common influence of time, consumption and the undeflated price and income variables were expressed as ratios to their respective trends.[4] The two variables explained 78 percent of the variation in per capita consumption from its trend level. The magnitude of the partial coefficients of determination tend to support the finding that changes in income are more important than changes in price in explaining variation in per capita consumption of cigarettes.

Results of Other Investigations

Statistical studies of the factors affecting demand for cigarettes have been relatively few. In one of the earliest, Schoenberg (*7*) related per capita cigarette consumption to real price and trend in the period 1913 to 1931. It was found that for each increase of $1 per 1,000 cigarettes at wholesale, annual per capita consumption de-

[4] See Schultz (*8*, p. 68) for a discussion of the rationale of this method. The following regression equation and statistical coefficients were obtained:

$$X_1' = 1.23 - \underset{(0.23)}{0.66}\, X_2' + \underset{(0.06)}{0.41}\, X_3' \qquad R^2_{1.23} = 0.78$$

$$s_{1.23} = 0.068$$

$$r^2_{12.3} = 0.25$$

$$r^2_{13.2} = 0.64$$

where X_1' is per capita consumption of cigarettes, X_2' is average retail price, and X_3' is per capita disposable income, all expressed as ratios to their respective trend values.

clined by about 22½ cigarettes and that there is an increase of about 52 cigarettes a year due to trend. An unsuccessful attempt was made to measure the relationship with income by introducing first an index of real wages for urban workers and then an index of factory payrolls. It was found that "the influence of 'time' was still paramount, and that 'time,' not earnings, accounted almost wholly for the high correlation."

A second analysis made by Schoenberg for the years 1923–31 added newspaper advertising expenditures by the four leading cigarette companies to those used in the foregoing analysis. This analysis yielded a price elasticity of −0.68 at the means. The author also estimated elasticities for selected prices and selected years. These ranged from −0.5 to −1.3, and indicated, according to the author, that the elasticity of demand for cigarettes had been decreasing with time and that it is higher for high prices than for low prices. However, as a linear demand curve was fitted to the data, it follows that the elasticity varies at different points and that it is higher at high than low prices. This is also pointed out by Tennant (*10*, pp. 148–151), who questions other aspects of Schoenberg's analysis. Gottsegen (*4*, pp. 166–171) also critically discusses the analysis.

A study by the U.S. Treasury Department (*11*), relating consumption to retail price, income, and trend in the years 1929–43, indicated a price elasticity of approximately −0.1. The income elasticity was indicated to be larger than the price elasticity, although neither any specific figure nor any details of the analysis itself were given. The greater influence of income, as found in the study, is also indicated by the following statement (p. 15): "Because of the apparent dominant effect of the income factor, it is difficult to measure the effect attributable to price changes. However, it seems reasonably certain that price changes have had much smaller effects on total consumption than equal percentage changes in income."

Tennant (*10*) presents estimates of the elasticity of demand for all tobacco products. But in his separate discussion of the demand for cigarettes, he does not include results of statistical analysis nor a quantitative estimate of the elasticity of demand for cigarettes. However, he states, "In normal years, cigarette demand is wholly inelastic within the range of observed price variations" (p. 173).

In an analysis of the factors affecting cigarette consumption by the Federal Reserve Bank of Richmond (*1*), per capita consumption was related to real price, real disposable income per capita and trend for the years 1929–48. The price elasticity of demand at the means was estimated at −0.66 and the income elasticity at 0.59. The most influential factors affecting consumption were found to be trend and income. Although it was stated that trend appeared to be a more important factor than income, the high intercorrelation between the two variables made it difficult to be definite on this point. The effect of price was found to be of "relatively minor importance" in explaining changes in cigarette consumption.

Another approach in measuring factors influencing consumption of cigarettes was taken by Maier (*5*). Geographic cross-section analysis was employed for each of the years 1947–51, in which purchases of cigarettes per person 15 years and over in States with State cigarette taxes were related to the following: Per capita disposable income, retail price, rural-urban composition and sex composition of the population. No statistically significant relationships with the last two variables were found, but even when these were dropped from the analysis low coefficients of determination were obtained with the remaining two determining variables—price and income—for each of the 5 years examined. The regression coefficients on income implied an income elasticity at the means of around 0.5 for most of the years. Regression coefficients on price were statistically significant for only 3 of the 5 years and implied a price elasticity in the State-wide markets at the mean prices in those years of from −1.08 to −1.48. The author advances several reasons for these large magnitudes.

In an analysis of cigarette consumption in the United Kingdom for the period 1920–38, Stone (*9*) estimated the elasticity with respect to the current year's price to be −0.39 and the elasticity with respect to income to be 0.22. In Stone's overall study of consumers' expenditures and behavior in the United Kingdom, budget studies were used to estimate income elasticities for most commodities. These income elasticities were then used to adjust the data in order to estimate price elasticities. In this manner, Stone sought to overcome the problem of intercorrelation between income and the other determining variables. This

procedure, however, was not followed in the analyses of cigarette consumption, because the usual understatement of tobacco expenditures in budget data made it unfeasible to introduce such "extraneous estimator" of the income elasticity. The analysis is thus based on time-series for all variables, but with use made of aggregate consumption and income in view of the "uncertainties" as to the size of the consuming public.

The estimate of the price elasticity of demand for cigarettes derived from analyses described earlier in this article generally is lower than that estimated in other U.S. investigations also based on time series; the income elasticity is generally in accord with those derived from previous studies. Although there are some differences in the elasticity measures, stemming in part from the type of curve fitted to the data, virtually all investigations are in agreement that the demand for cigarettes is inelastic, both with respect to price and income.

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