*Bulletin of Economic Research* 51:3, 1999, 0307-3378

# THE GRADUAL RESPONSE OF CIGARETTE DEMAND TO HEALTH INFORMATION

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ABSTRACT

The paper focuses on the US cigarette industry and uses a gradual switching regression model to estimate changes in the US demand for cigarettes over time. This technique is found to be superior to the use of dummy variables in capturing the health scare. The results show that cigarette demand gradually decreased over a ten-year period coinciding with the release of key health information. Price and advertising elasticities have gradually diminished, which is consistent with a change in the mix of US consumers before and after the switch.

## I. INTRODUCTION

The market demand for cigarettes has been studied extensively since the adverse health effects of smoking were first publicized. For example, using intercept dummy variables to capture information shocks, most studies find that *per capita* consumption fell in response to the release of new health information. Yet given the addictive nature of the product, coupled with the fact that the adverse health effects of smoking are not immediately apparent to consumers, it is plausible that consumer reaction to such information may have been gradual rather than immediate. Consequently, this paper uses a gradual switching regression model to estimate the US demand for cigarettes in the era of increasing information concerning the health risks of smoking.

In Section II, we review the traditional dummy variable technique used to capture health information releases and offer reasons why such a technique is limited in capturing the changes in market demand. Section

III outlines the gradual switching regression model and Section IV provides the results.

## II. LIMITATIONS OF PREVIOUS RESEARCH

The 1964 US Surgeon General report and subsequent policy initiatives related to the health problems associated with smoking (labelled the 'health scare') have been modelled empirically with time-series data by several researchers using intercept dummy variables in the US market demand for cigarettes (Hamilton, 1974; Bishop and Yoo, 1985; Porter, 1986; Kao and Tremblay, 1988). These studies generally find a decline in US cigarette demand, evidenced by a decrease in the intercept, after the information shock.

There are several reasons why the use of an intercept dummy variable may not be appropriate in modelling the link between health information and cigarette demand. For example, using a dummy variable assumes that the effect of the information shock is immediate, but according to Schneider *et al.* (1981) consumer adjustment to health information takes time. The lag in consumer adjustment can be attributed to the addictive nature of the product, the perceived credibility of the health information, and the learning time associated with incorporating new information to change old habits. A more appropriate method to uncover the effects of the health scare on US cigarette demand would allow for a gradual response of demand to health information.

Another limitation of using an intercept dummy variable is that it allows only for a change in the *level* of cigarette consumption. Yet it is quite possible that new information also affects the response or *elasticities* of cigarette demand to key variables (e.g. price, advertising and income). This is particularly important if one considers that the US market for cigarettes may consist of consumers who have different risk preferences and valuations of future health. Studies of individual consumer demand that use cross-sectional survey data (Viscusi, 1990,1991) show differences in smoking behaviour between consumers with different risk preferences. Also, Farrell and Fuchs (1982) find that age and education affect the probability of smoking. Since most of the adverse effects of smoking are not apparent until later years, different consumers may associate varying degrees of discounting of present consumption for future health benefits. Thus, perhaps the initial market for cigarettes consisted of consumers of many types, as health was a less publicized concern in cigarette consumption. Subsequent to the volume of health information, however, risk-averse consumers and consumers with a higher valuation of future health may have exited or not entered the market, affecting not only the level of consumption (intercept term) but also the market demand elasticities.

Given that studies assessing the effect of health information on cigarette demand use time-series data, whereas studies assessing the effect of risk preferences, age and education on cigarette demand use cross-sectional data, an ideal approach to reconcile these studies would be to use panel data. One could then determine the link between cigarette consumption, health information, risk preferences, age and education over time for different types of consumers. Unfortunately, given the lack of available data, this approach is not feasible. However, we can estimate a gradual switching regression model of US cigarette demand using time-series data, and from the results infer whether or not they are consistent with a change in consumer characteristics.

## III. GRADUAL SWITCHING REGRESSION MODEL

In common with other studies we model US cigarette demand by assuming *per capita* cigarette consumption $C_t$ in year $t$ depends on the price of cigarettes, $P_t$, *per capita* disposable income, $I_t$, *per capita* cigarette advertising, $A_t$, and *per capita* consumption in year $t-1$, $C_{t-1}$.[1] Unlike other studies, however, we allow the demand intercept and elasticities to adjust over time by adopting the following switching regression version of cigarette demand:

$$C_t = (\beta_0 + \lambda_t\delta_0) + (\beta_1 + \lambda_t\delta_1)P_t + (\beta_2 + \lambda_t\delta_2)I_t + (\beta_3 + \lambda_t\delta_3)A_t + \beta_4 C_{t-1} \tag{1}$$

where $\lambda_t$ is a transition path which accounts for an adjustment over time of the $i$th coefficient from $\beta_i$ to $(\beta_i + \delta_i)$.

Following Ohtani and Katayama (1985) and Ohtani *et al.* (1990), we let $\lambda_t$ vary over time along a linear transition path, given by

$$\lambda_t \begin{cases} = 0 & \text{for } t < t_1^* \\ = a_0 + a_1 t & \text{for } t_1^* \leqslant t \leqslant t_2^* \\ = 1 & \text{for } t > t_2^* \end{cases} \tag{2}$$

where $a_0$ and $a_1$, are unknown parameters, $t_1^*$ is the end-point of the first regime (where the coefficient is simply $\beta_i$), and $t_2^*$ is the start-point of the

[1] All variables are in natural logs, such that the coefficients correspond to elasticities. Also, given that advertising has a potentially prolonged effect on consumption (McGuiness and Cowling, 1975), we let demand depend on the stock of advertising, which is measured as a weighted sum of current and one- and two-period lagged advertising. Following Schneider *et al.* (1981), we assume the effect of advertising on sales depreciate at a 0.33 rate each period. Finally, similar to Kao and Tremblay (1988) and McGuiness and Cowling (1975), given the habitual nature of cigarettes, lagged consumption is included in the demand equation. See the Appendix for a description of the data.

second regime (where the coefficient becomes $\beta_i + \delta_i$). Given (2) it can be shown that, for $t_1^* \leqslant t \leqslant t_2^*$:

$$\lambda_t = (t - t_1^*)/(t_2^* - t_1^*). \tag{3}$$

Rather than assume arbitrary regime dates, a grid search is used to obtain the start- and end-points of gradual change. Specifically, substituting (3) into (2), and the resulting expression into (1), equation (1) is estimated across all possible values of the start- and end-points. The reported values of $t_1^*$ and $t_2^*$, as well as the estimates of $\beta_i$ and $\delta_i$, are those corresponding to the iteration which optimizes the estimation objective function.[2]

## IV. EMPIRICAL RESULTS

Table 1 provides the results from the estimation of equation (1). Given the low value of the Durbin $h$ statistic, the demand equation was not adjusted for serial correlation of the error term. As the estimates reveal, although the US Surgeon General's report of the health risks of smoking was released in 1964, viewed by many to be the first significant public release of health information in the US, the market demand for cigarettes began to decline in 1961. Yet the fact that market demand started declining three years prior to the 1964 Surgeon General's warning is not so surprising if one takes into consideration that the adverse health effects of smoking were being discussed by the medical profession well before the official warning.[3] The beginning and end of the adjustment period ($t_1^*$ and $t_2^*$) show that it took the market ten years to adjust fully.

Except for the income elasticity parameters, all of the estimated $\beta$ and $\delta$ are statistically significant. For example, as in other studies, we see a decrease in the intercept from 6.612 before 1961 to 1.452 after 1971, reflecting a general decline in demand. Yet given that our results also show an adjustment of key elasticities over time, important features of the demand for cigarettes are overlooked by studies that focus on a shift of the demand curve. In particular, while the market demand for cigarettes was price-elastic before the adjustment, the price elasticity declined substantially after the adjustment (from $-2.371$ before 1961 to

[2] Since the price of cigarettes is endogenous, two-stage least-squares is used to estimate the demand equation. The set of instruments (in natural logs) include *per capita* disposable income, the *per capita* advertising stock, the average hourly wage of a cigarette worker, the tax per pack of cigarettes, the price of tobacco, and a time trend.

[3] For example, in 1953 the American Cancer Society and the British Medical Research Council published a report on the adverse health effects of smoking. Given the evidence up to that point, it may well be argued that the 1964 warning was itself a consequence of the growing awareness among the public of the health effects of smoking.

TABLE 1
*Estimation results (t-statistics are in parentheses)*

| *Variable* | *Initial coefficient* ($\beta$) | *Adjustment* ($\delta$) | *Final coefficient* ($\beta+\delta$) |
|---|---|---|---|
| Intercept | 6.612[a] | −5.160[a] | 1.452[b] |
| | (3.249) | (−3.363) | (2.148) |
| Price | −2.371[b] | 2.230[c] | −0.141[c] |
| | (−2.053) | (1.955) | (−1.843) |
| Income | 0.200 | −0.157 | 0.043 |
| | (0.624) | (−0.484) | (0.514) |
| Advertising | 0.652[b] | −0.644[a] | 0.008 |
| | (2.574) | (−2.730) | (0.408) |
| Lagged consumption | 0.752[a] | | |
| | (6.128) | | |

Points of transition: $t_1^* = 1961$; $t_2^* = 1971$
Coefficients of transition path: $a_0 = -0.7$; $a_1 = 0.1$
Durbin $h$ statistic = 0.24
$R^2 = 0.978$

[a] Significant at the 1% level; [b] at the 5% level; [c] at the 10% level.

−0.141 after 1971). Similarly, the advertising elasticity declined from +0.652 before 1961 to +0.008 after 1971 (which is insignificantly different from zero).[4] Finally, lagged consumption has a strong and significantly positive effect on current consumption.

The results for the adjustment of the market demand for cigarettes are consistent with consumer theory and cross-sectional studies that focus on differences in consumers. First, the positive effect of lagged consumption, coupled with the gradual adjustment of demand, conforms to the habit-formation model of Pollack and Wales (1969), as well as Schneider *et al.*'s (1981) finding that consumer response to health information is not immediate. Second, models developed by Viscusi (1990, 1991) and Farrell and Fuchs (1982) show that the market for cigarettes consists of heterogeneous consumers who differ in their risk preferences, discounting, age, level of education and attitudes/investments in health. Given this, one explanation for the decline in the elasticities of market demand rests upon changes in the composition of market demand over time. In particular, prior to the

[4] Several policy implications emerge from these results. First, given the lack of price responsiveness after 1971, increasing cigarette tax rates will have little affect on consumption. Tax revenue, on the other hand, will greatly appreciate. Second, policies designed to limit cigarette advertising (such as banning television and radio advertising) do not significantly reduce consumption.

release and assimilation of the risks of cigarette smoking, market demand may have consisted of many types of consumers. After the increased awareness of the adverse health effects of smoking and a general decline in social acceptability of smoking, consumers with high-risk discounting, higher levels of education and investments in health, and lower levels of addiction may have exited the market. Subsequent to the adjustment, the market may consist of consumers who have higher levels of addiction and lower levels of risk discounting and investments in health, thus leading to less sensitivity to price and advertising.

## V. CONCLUSION

Our empirical results show that overall consumption of cigarettes in the US has declined in the wake of the health scare. In addition, we provide evidence that (1) cigarette demand declined gradually over time rather than instantaneously, and (2) the absolute values of the price and advertising elasticities have declined. This evidence is important, as it provides a conduit between the time-series studies of market demand and the cross-sectional studies of individual consumer demand for cigarettes. In particular, it may be that the gradual adjustment of key demand elasticities over time is linked to a shift in consumption towards less risk-averse and more addictive consumers.

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*Received July 1998*
*Final version accepted October 1998*

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## APPENDIX: DATA SOURCES

The data were gathered from several annual sources over the 1955–90 period. Cigarette consumption, price, and tax per pack data were obtained from the Tobacco Institute (1996). Disposable income data were obtained from the Council of Economic Advisors (1995). Data on cigarette advertising expenditure and tobacco price came from Schmalensee (1972) and the US Department of Agriculture (1992). Hourly cigarette wage data were collected from the US Department of Labor (1995). Finally, consumption, advertising, and income were converted into *per capita* terms (of persons 18 years and older) using US population data collected from the US Department of Commerce (1989, 1995).