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This dissertation addresses issues of oligopoly markets where advertising plays a prominent role. The first study empirically investigates the effect of advertising regulations on equilibrium consumption of an addictive commodity using U.S. cigarette industry data. The results of the first study show that the advertising regulations reduced cigarette consumption by increasing the industry's market power. In addition we find that a representative smoker is relatively impatient, an expected outcome for a commodity like cigarettes, where physical dependence, procrastination, and cognitive dissonance would lead to a high rate of time preference. In the second study, by using the same data set, we look at the effect of advertising regulations on the supply side of firm's cost minimization behavior. Economic theory provides two alternative hypotheses, which are investigated empirically. According to the LeChatelier principle, regulations that limit substitution possibilities among inputs will reduce efficiency. Alternatively, a prisoner's dilemma game in advertising suggests that advertising regulations may have a coordination effect which leads to higher efficiency. We use Data Envelopment Analysis to determine which effect is dominant. The results show that the Broadcast Advertising Ban in 1971 improved the industry's cost efficiency, implying that the coordination effect dominates the LeChaterlier effect. The third study addresses the effect of advertising on the market structure and performance using U.S. brewing industry data. The results indicate that an increase in the minimum efficient scale and a high advertising intensity are primal causes of rising concentration in the U.S. brewing industry. This finding is consistent with Sutton's (1992) prediction. We also find empirical evidence of market power at very high levels of concentration.

Dynamic Issues in Applied Microeconomics: Market Performance, Market Structure and Advertising Competition

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I understand that my dissertation will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my dissertation to any reader upon request.

Natsuko Iwasaki, Author

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CONTRIBUTION OF AUTHORS

Dr. Carol Tremblay provided ideas and assistance in all aspects of this dissertation. Dr. Rolf Färe and Dr. Shawna Grosskopf contributed basic ideas and helped with the implementation of the second manuscript. Dr. Barry Seldon provided ideas and suggestions for the third manuscript.

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Chapter 1

Introduction

This dissertation addresses issues of oligopoly markets where advertising plays a prominent role. Chapter 2 shows empirically the effect of advertising regulations on the market equilibrium. Chapter 3 looks at the effect of advertising regulations on firms' competitive behavior and cost efficiency. Chapter 4 studies the effect of advertising competition on market structure and performance when advertising intensity, concentration and profitability are simultaneously determined and evolved dynamically.

In Chapter 2, we use the U.S. cigarette industry data to study the effect of advertising regulations on the equilibrium cigarette consumption in the shortrun and the longrun. Previous studies conclude that advertising restrictions are ineffective in reducing cigarette consumption. This conclusion is incorrect because it ignores the fact that advertising restrictions have both supply and demand effects. We define the supply relation and demand function that are motivated by the dynamic optimization problem. In particular, we construct two models under alternative assumptions on consumer behavior of an addictive commodity: one is the myopic addiction model and the other is the Becker and Murphy (1986) model of rational addiction.

In Chapter 3, we use a comprehensive data set on advertising expenditures by media type from the U.S. cigarette industry and look at how advertising regulations affect the industry's cost efficiency and allocative efficiency. There are two potential consequences. The LeChatelier Principle suggests that a regulation that constrains firms' long-run substitution possibilities leads to lower cost efficiency. Alternatively, a prisoner's dilemma game in advertising suggests that advertising regulations may have a coordination effect which leads to a higher cost efficiency. We use Data Envelopment Analysis to determine which effect dominates.

In Chapter 4, we use U.S. brewing industry data to address the extent to which advertising plays a role in rising concentration. An advertising function is specified as a part of a system that also consists of profitability and concentration equations. Our study is similar to the past studies that adopt a system approach to inter-industry data. Although these previous studies are successful in finding an inter-industry regularity, they are often criticized for a lack of analytical framework. To circumvent this problem, we use single industry data and develop two systems: one is consistent with Martin (1978) and one is consistent with Sutton (1992). In the second approach, we redefine a system as the first order condition of an oligopoly game. Two alternative systems will be estimated using nonlinear three-stage least squares.

These chapters are all concerned about economic issues of advertising in oligopoly markets. All studies covered in chapter two, three and four are further linked by their use of microeconomic theory.

Advertising Restrictions and Cigarette Smoking: Evidence from Myopic and Rational Addiction Models

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2.1 Introduction

As the leading cause of preventable mortality in the U.S., cigarette smoking imposes a tremendous cost on society. Sloan et al. (2004) estimate that each year smoking causes approximately 400,000 deaths and $104 billion in social costs. Of this amount, $35 billion is external to individual cigarette smokers. In spite of these known private and external costs associated with cigarette smoking, approximately 17 percent of U.S. adults continue to smoke cigarettes [Centers for Disease Control and Prevention (2002)].[1]

To reduce cigarette smoking, many countries have imposed various advertising restrictions. For example, the U.S. enacted the Fairness Doctrine Act, effective 1968-70, which required that one anti-smoking advertisement be aired for every four pro-smoking advertisements on television and radio. In 1971 the U.S. Broadcast Advertising Ban supplanted the Fairness Doctrine Act by abolishing all cigarette (pro- and anti-smoking) advertising from television and radio. At the end of 1998, the U.S. tobacco industry and 46 states forged an agreement, the National Tobacco Settlement, that prohibits outdoor advertising, bans tobacco companies from using cartoon characters to market their products, and provides funding for anti-smoking advertising [Nader (1998), Shapiro (1998), and Teinowitz (1998)].

A growing body of evidence has shown, however, that advertising bans have no significant effect on cigarette demand.[2] For example, in a study of 22 OECD countries, Stewart (1993) finds that advertising bans may actually stimulate cigarette smoking. Schneider et al. (1981) find that the Broadcast Advertising Ban increased cigarette smoking in the U.S., arguing that this was due to the elimination of both pro- and anti-smoking advertising. In a review article of international studies concerning the relationship between advertising and cigarette smoking, Duffy (1996, p. 20) concludes:

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[1] For a discussion of the history of public health research on cigarette smoking, see Hammerle (1992) and Kluger (1996).

[2] In their reviews of the literature, Smart (1988), Bang (1998), Hacker (1998), Coulson et al. (2001), and Tremblay and Tremblay (2005) come to a similar conclusion regarding the effect of advertising on the consumption of alcoholic beverages.

> Taken as a whole, these studies, American and otherwise, provide very little support for those who believe that a broadcast advertising ban is a potent way of achieving significant changes in smoking behavior.

Given the high cost and the subsequent social goal of deterring smoking, understanding the consequences of advertising restrictions is critical to establishing appropriate public policy. Tremblay and Tremblay (1999) argue that the counterintuitive conclusion of Duffy (1996) and others may be incorrect because it ignores the supply side effects of advertising. Their model shows that even when advertising has no effect on market demand, an advertising ban can still cause a dramatic fall in the equilibrium level of cigarette smoking if advertising has pro-competitive supply effects. Farr et al. (2001) find empirical support for this hypothesis in the short run using a myopic addiction model.

In contrast to previous work, we compare the short-run and long-run effects of advertising restrictions on cigarette smoking for both myopic and rational addiction models. In myopic addiction models consumers have no foresight, so previous consumption affects current consumption, but future consumption bears no influence. When consumers are rationally addicted [Becker and Murphy (1988)], they also look forward so that current consumption may depend on expected future as well as past consumption. Although there has been empirical support for the rational addiction model [Chaloupka (1991), Becker et al. (1994), Olekalns and Bardsley (1996), Fenn et al. (2001), and Sloan et al. (2002)], it has not gone unchallenged. For example, Akerlof (1991) shows that procrastination can negate foresight. In Akerlof's model, consumers ignore the future because the present is unduly salient. A consumer who wants to quit smoking because of an increase in expected future prices, for example, may find it optimal to postpone quitting for a day, as the benefit of smoking now is high relative to the cost of waiting one day to quit. Day-by-day optimization leads the consumer to continue smoking despite the intention to quit. In addition, cigarette smokers may suffer from cognitive dissonance [Akerlof and Dickens (1982)]. That is, consumers who smoke and value health face an inconsistency that creates internal conflict. One response is to ignore the future and downplay public health warnings concerning smoking cigarettes.[3] If cognitive dissonance and procrastination are important, then the effect of expected future consumption on current consumption will be small and the myopic and rational addiction models will yield similar results.[4]

To see if this is the case, we develop two empirical models of the cigarette market, one with myopic addiction and one with rational addiction, to examine the effect of advertising restrictions on the equilibrium level of cigarette consumption. That is, we estimate the change in equilibrium consumption from an unregulated to a regulated environment where the Fairness Doctrine Act, the Broadcast Advertising Ban, and the National Tobacco Settlement are in effect. As well as shedding light on these policy issues, the results will expose any differences in estimates for the rational addiction model and the myopic addiction model.

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[3] This is consistent with Schoenbaum (1997, 755), who finds that "heavy smokers significantly underestimate their risk of premature mortality."

[4] Even when consumers are not rationally addicted, however, supply forces like learning-by-doing may also cause the optimal path of current consumption to be influenced by expected future effects [Pindyck (1985) and Showalter (1999)].

2.2 Theoretical Background

2.2.1 Demand

Economic analysis of consumer behavior about addictive goods is based on an endogenous taste (habit formation) model. Houthakker and Taylor (1966) were the first to include the lagged consumption as a determinant of current consumption. Pollak (1970, 1978) establishes the theoretical justification of dynamic nature of consumer's behavior and proved the existence of stable equilibrium consumption. The myopic model emerged and was tested with cigarette consumption from the late 1960s through early 1980s. Despite its popularity, there are several critiques on this specification. A main concern is on an assumption of rationality because consuming harmful goods that may reduce consumers' future utility seems to be inconsistent with rational behavior.

The rationality of consumers regarding addictive goods is first justified by Becker and Murphy's (1986) model of rational addiction. In their model, the consumer maximizes his life-time utility discounted with rate of time preference subject to the budget constraint. The utility function that will be maximized is defined as

$$(2.1) \qquad \max \sum_{t=1}^{\infty} \delta^{t-1} U(Y_t, Q_t, \phi(Q_{t-1}))$$
$$s.t. \sum_{t=1}^{\infty} \delta^{t-1} (Y_t + p_t Q_t) = W^0$$

where Y_t is a consumption of composite commodity at time t, Q_t is the consumption of commodity that may accumulate a stock of past consumption, which is measured by $\phi(Q_{t-1})$, p_t is a price of addictive commodity, and W^0 is a present value of wealth. Also a dynamic optimization implies that he or she is a forward looking. Finally, the individual's choices over time will depend on how he or she feels about the relative importance of consuming currently or waiting to consume in the future. To reflect the possibility that people may exhibit some impatience in their choices, we assume that the utility from future consumption is implicitly discounted in the individual's mind. We define discount factor $\delta = 1/(1+r)$, where r measures the rate of time preference and a lower δ implies greater impatience.

The shadow price of addictive goods is a sum of its market price and the money value of the future cost or benefit of consumption. A rational consumer can be addicted when the increasing marginal utility due to the addiction is greater than the increasing full price of its consumption over time. If the consumer is fully rational, the rate of time preference *r* should coincide with a market interest rate r^*, that is $\delta = \delta^*$ where $\delta^* = 1/(1 + r^*)$. On the other hand, if consumers are fully myopic, the discount factor is zero ($\delta = 0$); that is, he ignores the future and he can be addicted whenever an increase in past consumption raises the marginal utility of current consumption. Note that when this happens, equation (2.1) will be reduced to

$$\max U(Y_t, Q_t, \phi(Q_{t-1})) \quad s.t. \quad Y_t + p_t Q_t = W_t \tag{2.2}$$

which is equivalent to the myopic addiction model. Hence, within the framework of the rational addiction model, myopic behavior is consistent with rational assumption in the sense that he is maximizing his utility given the high level of discount rate.

On the other hand, in Akerlof's (1991) model, the possible higher discounting rate for the addictive goods than for non-addictive goods can be explained as an error due to the procrastination as well as the more present oriented nature of average addicts. He argues that individuals' decisions on addictive drugs cannot be compatible with forward-looking and rational behavior. In his argument, "individuals following the procrastination model are both maximizing and knowledgeable, and yet their decisions are not fully rational." In fact, many smokers have an intention to quit because they recognize that the long-run cost of smoking exceeds its benefit.

On the regard of bounded rationality [Simon (1955)], consumers' behavior on addictive commodities can hardly be rational. Because a consequence of smoking is remote in time and probabilistic, rather than maximizing over the present value of life time utility, consumers would maximize their utility day-by-day, knowing the bad consequence of smoking in the distant future. Consequently, they would face the dynamic inconsistency in decision making and large cumulative cost of errors of decision later of their life. Suranovic et al. (1999) develop the model of cigarette addiction. They showed that by the time smokers realize the net benefit of smoking is negative due to high health cost, they regret they started smoking during an earlier stage of their life, but cannot quit smoking since quitting will worsen their utility due to accumulated addiction by this time. In the day-by-day optimization model argued in Akerlof (1991) and Suranovic et al. (1999), the discount rate would be smaller than that of the rational addiction model but greater than zero, that is $0<\delta<\delta^*$.

By solving the problem defined in (2.1), we obtain an inverse demand function

$$p_t = p_t(Q_t, \phi(Q_{t-1}), \delta\phi(Q_{t+1}), \underline{x}_t). \tag{2.3}$$

The consumption at time *t* is a function of past consumption (Q_{t-1}), the level of addiction (ϕ), and a vector of other relevant demand variables such as advertising and consumer income ($\underline{x}_t$). An increase in current consumption increases the degree of addiction and therefore market demand in the next period. If people are rationally addicted, an expected increase in the future price would decrease future consumption and therefore current market demand. Future effects would be discounted, however, given the degree of consumer foresight and rate of time preference, which are captured by the discount factor, δ $(0 \leq \delta < 1)$.[5] When $\delta = 0$, consumers ignore the future and are myopically addicted. In this case we can say that consumers are infinitely impatient. Consumers are rationally addicted when they have at least some patience and foresight (i.e., $\delta > 0$), and current demand will depend on consumption in the previous period, $\phi(q_{t-1})$ and on expected consumption in the future, $\delta\phi(q_{t+1})$ [Becker et al. (1994) and Fenn et al. (2001)].

2.2.2. Supply

Given the addictive nature of cigarettes, current sales affect a firm's current and future profits. In this setting, the firm's problem in the current period ($t = 0$) is to choose the sequence of firm output levels (q) that maximizes its discounted stream of current and future profit (Π). More formally, the firm's problem is:

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[5] For example, a value of $\delta = 0.6$ implies that a smoker would be willing to give up no more than 60 cigarettes today to receive 100 cigarettes in the next period. A lower discount factor implies greater impatience. It may also imply greater uncertainty about the future, causing consumers to place less weight on expected future events.

$$\max \Pi_0 = \sum_{t=0}^{\infty} \delta^t \left[\{ p_t(\cdot) - mc_t \} q_t - F_t \right]$$

(2.4) s.t.

$$\phi(t+1) = f(t, \phi(t), q(t))$$
$$\phi(0) = \phi_0$$
$$q(t) \in \Omega_t$$

where mc_t is marginal cost, and F_t is fixed cost. The objective function is maximized, subject to the dynamic updating rule that links addiction in period t+1 with addiction and consumption in period t, given an initial value of addiction (ϕ_0) and given that the choice of output is an element of the feasible set (Ω_t).

A firm's economic problem in this industry is dynamic and can be solved recursively using dynamic programming methods.[6] Let the value function, V_{k+1}, be the maximized value of the objective function of the sub-problem in period k+1. Assuming a solution exists, the Bellman equation or value function in period k ($0 \leq k < \infty$) can be written as:

(2.5)
$$V_k = \max_{q \in \Omega_k} [\{ p_k(\cdot) - mc_k \} q_k - F_k + V_{k+1}]$$

subject to the constraints described above. Because of addiction, an output change in period k will affect current and future profit. This tradeoff can be seen from the firm's first order condition:

(2.6)
$$[p_k - \theta q_k - mc_k] + \frac{\partial V_{k+1}}{\partial q_{ik}} = 0 .$$

The term in brackets is the standard first order condition of the firm's static problem in the absence of addiction, where θ is a markup or market power index. Equation (2.6) can be rewritten as a price-cost margin:

(2.7)
$$\frac{p_k - mc_k}{p} = \theta q_k - \frac{\partial V_{k+1}}{\partial q_{ik}} .$$

In the static model, the equilibrium price exceeds marginal cost when θ exceeds zero. With addiction, however, it may be optimal for a firm to substantially lower current price, because this will increase addiction and future profits. This inter-temporal trade-off effect appears as the last

[6] See Novshek (1993) for a more complete description of dynamic programming.

term in equation (2.6) and (2.7). As a result, the price-cost margins or Lerner index underestimates the degree of market power in markets with addiction [Pindyck (1985)]. Solving equation (2.6) for price produces a dynamic version of the supply relation found in the new empirical industrial organization [Bresnahan (1989) and Kadiyali et al. (2001)]. Assuming constant marginal cost, the supply relation in period *t* can be aggregated to the industry level:

(2.8) $$p_t = mc_t + \theta Q_t - V_{t+1}^{'},$$

where Q is industry output and V' is the effect of a change in current output on the aggregate value function in the future.

2.3 Empirical Model

In addition to the variables affecting smoking in equations (2.4) and (2.8), advertising enters the model in the demand equation and may also affect the supply relation. For example, advertising that is primarily informative will raise competition and lower markups [Bagwell (2003) and Carlton and Perloff (2005)]. The results from Eckard (1991) and Farr et al. (2001) suggest that anti-smoking advertising and the Broadcast Advertising Ban have increased price-cost margins in the U.S. cigarette industry. We estimate how advertising affects cigarette consumption when unregulated and when regulated by the Fairness Doctrine Act, the Broadcast Advertising Ban, and the National Tobacco Settlement. Estimates are obtained from a reduced form model of the equilibrium level of consumption, which derives from the structural demand function and supply relation above. The advantage of using the reduced form is that it places limited structure on demand and supply and allows us to directly estimate the effect of a change in advertising policy on the equilibrium level of consumption [Griffiths, Hill, and Judge (1993) and Kadiyali et al. (2001)]. We model the industry supply relation in period t as follows.[7]

(2.9) $$p_t = f_s(mc_t, Q_t, A_t D_{55-67}, A_t D_{68-70}, A_t D_{71-97}, A_t D_{98-02}).$$

In this specification, A_t is industry advertising. The influence of advertising on supply under the Fairness Doctrine Act is captured by interacting A_t with $D_{68\text{-}70}$, a dummy variable that equals 1 when the Fairness Doctrine was in effect (1968-1970) and 0 otherwise. Likewise, the model also includes advertising interaction terms for the Broadcast Advertising Ban ($A_tD_{71\text{-}97}$), and the National Tobacco Settlement ($A_tD_{98\text{-}02}$). Because the Broadcast Advertising Ban is still in force, the $D_{98\text{-}02}$ dummy variable represents the regulatory states of the Ban and the Settlement. Finally, cigarette advertising was unregulated prior to 1968, and the effect of advertising during this period is captured by the advertising interaction term, $A_tD_{55\text{-}67}$.

[7] Following Roberts and Samuelson (1988), Jarmin (1994), and Genesove and Mullin (1998), we use a constant term and a variable parameter for marginal cost to capture dynamic effects and increase model flexibility.

Specification of the market demand for cigarettes in equation (2.3) follows previous research. Since the marginal effect of advertising on demand may vary by marketing medium [Porter (1977)], we also allow the effect of advertising to differ by policy regime in the demand function.[8] Information about the health risks of smoking will affect the smoking behavior of rational consumers. This effect is captured by a dummy variable (D_{64}) that coincides with the U.S. Surgeon General's 1964 report, the first to conclude that cigarette smoking causes lung cancer. D_{64} equals 1 from 1964 on, and 0 otherwise. Furthermore, Chaloupka (1991 and 1992) finds that the clean indoor air laws have a significant negative impact on average cigarette consumption. As a result, we construct a variable that accounts for the increasing restrictiveness of indoor smoking, LAW_t.[9] From demand theory, consumer income may also be an important demand determinant. Consequently, per-capita cigarette demand in period t (pcq_t) is defined as:

(2.10)
$$pcq_t = f_D(p_t, pcy_t, pcq_{t-1}, pcq_{t+1}, D_{64}, LAW_t, A_tD_{55-67}, A_tD_{68-70}, A_tD_{71-97}, A_tD_{98-02})$$

where pcy is per-capita disposable income.

The reduced form of this system is obtained by solving equations (2.9) and (2.10) simultaneously for pcq_t. Assuming it can be accurately approximated by a linear specification, the statistical model of the reduced form is:

(2.11)
$$pcq_t = \pi_0 + \pi_1 mc_t + \pi_2 pcy_t + \pi_3 pcq_{t-1} + \pi_4 pcq_{t+1} + \pi_5 D_{64} + \pi_6 LAW_t + \pi_7 AD_{55-67} + \pi_8 AD_{68-70} + \pi_9 AD_{71-97} + \pi_{10} AD_{98-02} + \varepsilon_t,$$

where the π's are reduced form parameters and ε_t is an additive error term. The model is myopic when δ and therefore π_4 equals zero.

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[8] One might also be concerned that past advertising affects current demand, but Boyd and Seldon (1990) find that cigarette advertising dissipates within one year. Thus, it has little effect on goodwill, and current advertising would primarily affect current consumption. See Bagwell (2003) for a review of this issue.

[9] This variable also reflects other demand forces that vary with time, such as the growing evidence and concern with the social costs of cigarette smoking. See the Appendix A for the definition of this variable.

Estimates of the model can be used to predict how a change in advertising policy will affect equilibrium consumption in the short run and the long run. Since the reduced form parameters capture the net effect of relevant demand and supply effects on consumption, they should be interpreted as such. For example, an increase in persuasive advertising may increase demand and reduce price competition. The increase in demand would increase equilibrium consumption, while the decrease in competition would lead to a higher price and lower equilibrium consumption. Thus, the net effect of advertising on consumption, which depends on the relative magnitudes of these effects, is ambiguous but can be obtained directly from the reduced form results. Methods used to obtain the short-run and long-run effects of an advertising policy on cigarette smoking are described in Appendix B.

2.4 Results

The rational and myopic addiction models are estimated using annual industry data, 1955-2002. The data are described in Appendix A and in Table A.1. As in previous studies [Becker et al. (1994), Fenn et al. (2001), and Sloan et al. (2002)], the rational addiction model is estimated by two-stage least squares.[10] The myopic model is estimated by ordinary least squares, since lagged output is predetermined.[11]

The empirical results are reported in Table 2.1. All parameter estimates have expected signs and many are significantly different from zero at conventional levels of significance. In both the rational and myopic models, the marginal cost has a negative effect and disposable income has a positive effect on consumption. Public health information and anti-smoking restrictions, captured by D_{64} and LAW_t, inhibit cigarette smoking.

Addiction plays an important role in the market as evidenced by the positive, significant, and relatively large coefficient estimates on lagged and future consumption. The large and significant parameter estimate of expected future consumption suggests that the rational addiction model provides a better representation of the cigarette market than the myopic addiction model. In the rational model, the coefficient on lagged consumption is greater than on future consumption, a result that is consistent with previous empirical studies [Becker et al. (1994), Fenn et al. (2001) and Sloan et al. (2002)]. Becker et al. (1994) show that the parameter on future consumption will equal the parameter on past consumption times the discount factor. Results from Table 2.2 suggest a discount factor of 0.78, for a rate of time preference of about 27 percent. A rate above the real interest rate or a risk free investment implies that the representative smoker is relatively impatient,

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[10] Output instruments include all current exogenous variables and all lagged and future values of all exogenous variables, farmers' tobacco allotment, and price.

[11] We also test for autocorrelation, using a modified Breusch-Godfrey test for the rational addiction model [Greene (2002)]. In both the rational and myopic models, no autocorrelation is detected.

an expected outcome for an addictive commodity like cigarettes where procrastination and cognitive dissonance are present.[12]

The advertising variables capture consumption effects through both the demand and the supply sides of the market. Although only one parameter is significantly different from zero, they exhibit a consistent pattern and imply that advertising restrictions negatively impact cigarette smoking. Focusing on the more relevant rational addiction results, advertising has a negligible effect on consumption when there are no advertising restrictions (1955-1967). This suggests that the demand and supply effects of advertising are nearly a wash. For each succeeding regime of policy restrictions, however, advertising has an increasing negative effect on consumption. The current advertising restrictions under the National Tobacco Settlement and the Broadcast Advertising Ban have the greatest effect, an effect that is negative and significantly different from zero. This suggests that the Advertising Ban and the National Tobacco Settlement diminish price competition and consumption, a result consistent with Eckard (1991) and Farr et al. (2001). The evidence indicates that these advertising restrictions reduce consumption, even if advertising has little or no effect on market demand as in earlier studies.

Table 2.2 provides estimates of the effect of the different advertising regimes on consumption, based on the parameter estimates of the model. We use actual consumption in 2002 as the reference point for our analysis. This is the last year of the sample, a year when both the Broadcast Advertising Ban and the provisions of the National Tobacco Settlement were in effect. We then predict 2002 levels of consumption that would result under three alternative policy settings: no advertising restriction, the Fairness Doctrine Act, and the Broadcast Advertising Ban (apart from the tobacco settlement). Table 2.2 shows that advertising restrictions substantially reduce the equilibrium level of consumption in the short and long run.[13] It also shows that the

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[12] Gruber and Koszegi (2000) make a similar argument, suggesting that there is additional discounting for addictive bads.

[13] Farr et al. (2001) use a myopic addiction model to evaluate the short-run effect of the Fairness Doctrine Act and the Broadcast Advertising Ban on cigarette smoking and find qualitatively similar results.

dynamic nature of addiction models produces greater long-term effects than short-term effects in both myopic and rational specifications.

Each advertising restriction becomes more effective at reducing cigarette smoking, with the current policy regime that includes the National Tobacco Settlement and the Broadcast Advertising Ban being most effective. This result is consistent with Keeler et al. (2003), who find that the price increase resulting from the National Tobacco Settlement reduced per-capita consumption even though advertising expenditures rose substantially immediately after the settlement.[14]

The magnitude of the impact of advertising regulations differs for the rational and myopic models. The difference in short-run predictions reflects differences in the parameter estimates between models. In the long run, policy changes are greater in the rational addiction model, since the lag and lead effects of addiction in the rational model exceed the single lagged effect in the myopic model. Consistent with the rational addiction model where consumers have foresight, long-run consumption falls when a policy is expected to lead to less competition and higher prices in the future.[15] Although the there is empirical support for the rational addiction model and magnitudes differ between the rational and myopic specifications, the lesson is the same: advertising restrictions result in less smoking, particularly under the Broadcast Advertising Ban and the National Tobacco Settlement.[16]

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[14] One should interpret the effect of the National Tobacco Settlement with caution, however, since it involves more than just restrictions on advertising. For example, it also supports funding for education programs that are designed to reduce teen smoking.

[15] The rational and myopic models also produce conflicting results for the Fairness Doctrine Act and the Broadcast Advertising Ban. However, these results derive from parameter estimates that are not statistically significant from one another.

[16] This conclusion holds for a variety of alternative specifications such as excluding D_{64}, using an alternative set of instrumental variables, and using the USDA estimate of cigarette consumption. Long-run forecasts become unstable, however, when we fail to use past and future prices as instruments and when we use the USDA estimate. Past and future prices are commonly used as instruments in dynamic models [Roberts and Samuelson (1988) and Becker et al. (1994)], and Chaloupka and Warner (2000) note that dynamic addiction models can be unstable.

2.5 Concluding Remarks

Many countries have imposed advertising restrictions to curtail the social cost associated with cigarette smoking. Previous research indicates, however, that advertising bans generally have no significant effect on demand. Unfortunately, this is interpreted to mean that such bans have no effect on the equilibrium level of consumption. This interpretation may be incorrect, however, since it ignores the fact that advertising can have supply as well as demand effects. Even if an advertising ban had no effect on demand, it could still reduce the equilibrium level of consumption if it reduced price competition.

To address this issue directly, we estimate a reduced form output equation for the U.S. cigarette industry. Unlike previous research, the model allows the effectiveness of advertising to vary with the Fairness Doctrine Act, the Broadcast Advertising Ban, and the National Tobacco Settlement. As expected, the empirical results indicate that the equilibrium level of cigarette smoking declines with higher marginal costs, more accurate health information, and with more restrictive clean-indoor-air regulations. Consistent with the rational addiction model, both past and expected future levels of consumption positively and significantly affect current consumption.

Finally, advertising restrictions, especially the current policy that includes a ban on broadcast advertising and the provisions of the National Advertising Settlement, reduce the equilibrium level of consumption. Since previous studies show that cigarette advertising has little or no effect on market demand, it appears that advertising restrictions lower consumption by reducing price competition. This provides one explanation for the observation that cigarette profits have risen in spite of public policies to decrease demand [Becker, Grossman, and Murphy (1994), Bulow and Klemperer (1998), and Farr et al. (2001)] and may help explain why the leading U.S. cigarette producers have not been strongly opposed to advertising restrictions. This is not to imply, however, that advertising restrictions are a first-best policy for cutting cigarette consumption. For example, one could design an equally effective tax policy, as Keeler et al. (1993) and Evans and Farrelly (1998) suggest, that has the same effect on consumption without profiting cigarette producers.

Although we find strong support for the rational addiction model, we also find that cigarette smokers have a high rate of time preference when considering the influence of future price changes on current behavior. This high rate is consistent with the tendency to procrastinate a decision to quit smoking and the cognitive dissonance associated with consuming unhealthy commodities.

Table 2.1
Rational and Myopic Model Estimates of the Equilibrium Level of Cigarette Smoking

Variable	Rational Addiction Model	Myopic Addiction Model
constant	.0375085	1.148731*
	(.75164)	(2.96274)
mc_t	-.086742	-.104510***
	(1.61045)	(1.9791)
pcy_t	.053878	.02654
	(1.529872)	(.68102)
pcq_{t-1}	.494288*	.770911*
	(3.99084)	(10.3651)
pcq_{t+1}	.387939**	-
	(2.4911)	
D_{64}	-.119833**	-.058779
	(2.05459)	(.821730)
LAW_t	-.004273	-.006712**
	(1.47067)	(2.31597)
AD_{55-67}	.046610	-.005656
	(.541345)	(.064456)
AD_{68-71}	.019519	-.059587
	(.228403)	(.75022)
AD_{71-97}	-.065145	-.052583
	(1.43408)	(1.11833)
AD_{98-02}	-.09164***	-.107740**
	(1.84096)	(2.2036)
R^2	.995217	.992137
N	46	46
Discount Factor (δ)	.7848	-

The absolute values of t-statistics are in parentheses.
*Significant at 0.01 level (two tailed test, critical t value = 2.690)
**Significant at 0.05 level (two tailed test, critical t value = 2.014)
***Significant at 0.10 level (two tailed test, critical t value = 1.679)

Table 2.2
Predicted Short-Run and the Long-Run Effects of an Advertising Regime Change

Advertising Regime	Rational Addiction Model	Myopic Addiction Model
Cigarette Consumption - Short-Run Effect of Advertising Regime Change		
Current Regime National Tobacco Settlement*	376.4	376.4
Broadcast Advertising Ban	391.4 (3.99%)	387.97 (3.07%)
Fairness Doctrine Act Regulation	439.34 (16.72%)	386.5 (2.68%)
No Regulations	454.68 (20.8%)	397.81 (5.69%)
Cigarette Consumption – Long-Run Effect of Advertising Regime Change		
Current Regime National Tobacco Settlement*	376.4	376.4
Broadcast Advertising Ban	503.78 (33.84%)	426.89 (13.41%)
Fairness Doctrine Act Regulation	910.81 (141.98%)	420.48 (11.71%)
No Regulations	1041.05 (176.58%)	469.85 (24.83%)

* The current regime of the National Tobacco Settlement includes the Broadcast Advertising Ban.

Chapter 3

The Effect of Advertising Regulations on Efficiency: LeChatelier Versus Coordination Effects

3.1 Introduction

Government regulations designed to promote the public interest frequently have unintended consequences. For example, regulation of the transportation sector of the U.S. before 1980 led to distortions in railroad and truck rates, inefficient non-price competition, and incentives that stifled innovation [Viscusi, Vernon, and Harrington (1995)]. To reduce the private and social costs that are caused by alcohol abuse, the federal government has imposed high excise taxes on alcoholic beverages. This is in spite of the evidence that high excise taxes and prices curb moderate consumption that may promote health but have little or no effect on alcohol abuse [Tremblay and Tremblay (2005)]. For similar reasons, the federal government has imposed excise taxes and severe marketing restrictions on cigarette producers.

Regulations that effectively constrain a firm's marketing or production activities will limit the firm's ability to adjust to changing market conditions. The LeChatelier Principle [Samuelson (1947) and Milgrom and Roberts (1996)] indicates that effective restrictions such as these will limit long-run substitution possibilities among inputs and reduce the efficiency of a regulated firm. The principle expresses mathematically the idea that the long-run firm demand for inputs is typically more elastic than the short-run demand at the point of the long-run equilibrium. An intuitive argument can be offered why this is true. Suppose there are two inputs x_1 and x_2 and assume that x_1 is fixed in the short-run. Also, suppose that the price of x_2 falls. In the short-run, firms will respond to the price change by using more x_2. In the long-run, the firm adjusts x_1, which increases a marginal productivity of x_2 and leads to more x_2 being employed.[17] The extra adjustment involved

[17]This argument is valid whether x_1 and x_2 are substitutes or complements. x_1 and x_2 are substitute when increasing the use of one reduces the marginal product of the other. When this is the case, in the long-run, a firm will reduce the use of x_1 which increases the marginal product of labor and leads to more x_2 being employed. On the other hand, if x_1 and x_2 are complement, the firm will respond to the lower price of x_2 and resultant short-run increase in x_2 by employing more x1 in the long-run. This raises the marginal product of x_2 and leads to a further increase in x_2 demand in the long-run.

in long-run demand creates a positive feedback that is missing from short-run demand. However, such a positive feedback in the long-run may be reduced if the regulation is constraining the x_1 adjustment and limiting the long-run substitution possibilities.

The lower cost efficiency due to the regulation predicted by the LeChatelier Principle is certainly true in competitive or monopoly markets, but firm efficiency may actually improve if a government restriction is placed on a strategic variable in an imperfectly competitive industry. To illustrate, consider a market with two symmetric firms that compete in purely predatory or combative advertising. That is, one firm's advertising steals customers from its rival but attracts no new customers to the market and has no effect on total market demand [Bagwell (2003)]. Since each firm will ignore the negative externality that its own advertising inflicts on its rival, the Nash equilibrium level will exceed the joint profit-maximizing level of advertising [Stivers and Tremblay (2005)]. In this setting, firms face a prisoner's dilemma: each firm's dominant strategy is to advertise more than is jointly profit maximizing. If the government imposes a regulation that reduces advertising spending, such a regulation enforces more cooperative behavior and will raise marketing efficiency, since each firm produces and sells the same level of output with less advertising.[18]

Given that marketing restrictions may facilitate coordination as well as constrain substitution possibilities, the main goal of our paper is to estimate the net effect of marketing restrictions on both marketing and production efficiency in the U.S. cigarette industry. This industry is an ideal candidate for such a study. It is imperfectly competitive, with the largest six producers accounting for over 90 percent of sales, and advertising has been an important strategic variable. In addition, the industry has been hit with several advertising restrictions, which are designed to reduce smoking and the negative externalities associated with cigarette smoking. The two most important regulations are the Broadcast Advertising Ban and the National Tobacco

[18] Of course, if advertising is constructive (i.e., it benefits both the firm and its rival), then firms will advertise less than is jointly profit maximizing and an advertising restriction will lower the marketing efficiency of both firms, ceteris paribus. The effect of an advertising restriction is even more complex when firms compete in both price and advertising. See Stivers and Tremblay (2005) and Tremblay (2005) for further discussion of the price effect of advertising.

Settlement. Since 1971, the Broadcast Advertising Ban has made it illegal to advertise cigarettes on television and radio. On November 23 of 1998, the tobacco industry and the attorneys general of 46 states agreed on the National Tobacco Settlement, which further restricted the marketing of cigarettes to youth.[19] For example, the agreement prohibits all outdoor advertisements, the use of cartoon characters to market cigarettes, and the distribution of clothing that carries cigarette brand name logos.

Eliminating all broadcast advertising would reduce marketing productivity if it forced cigarette producers to use less efficient marketing alternatives, as the LeChatelier Principle suggests. Marketing productivity will tend to rise, however, if these restrictions facilitate coordination in advertising. Coordination is likely to be important in the U.S. cigarette market, since recent empirical evidence suggests that cigarette advertising is combative [Farr et al. (2001), and Nelson (2003)]. For this reason, the net effect of an advertising restriction on efficiency is ambiguous.

This is the first study to analyze the effect of marketing regulations on an industry's ability to use its production and marketing inputs efficiently. Previous studies of marketing efficiency have assumed that the production and marketing components of a firm are separable, as in Bresnahan (1984), Seldon et al. (2000), and Färe et al. (2004), and Vardanyan and Tremblay (forthcoming). We allow for a more general specification, since one of our goals is to determine if

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[19] In response to lawsuits designed to recover states' tobacco-related health care costs, the cigarette industry agreed to the National Tobacco Settlement. Four other states (Florida, Minnesota, Mississippi, and Texas) previously settled their lawsuits against the cigarette industry. As well as marketing restrictions, the Settlement included cash payments to states, funds that could be used to pay for these health-care expenses and to develop smoking-prevention programs. The settlement required the industry to pay $2.4 billion annually from December 1998 through 2003 and an additional $183.177 billion over a 25 year period, beginning in 2000. In 2000 and 2001 the payment was $4.5 billion annually, and it was $6.5 billion in 2002. The industry was also required to contribute $325 million annually to the National Foundation and National Public Education Fund, 1999 through 2003. The Settlement requires that the payments be inflation adjusted, based on a 3 percent increase or the Consumer Price Index, whichever is greater. Consequently, after adjusting for the inflation, the payments are calculated as $2.4 billion (1998), $2.8 billion (1999), $7.6 billion (2000), $8.6 billion (2001) and $11 billion (2002). For further discussion of the Settlement, see the Data Appendix, Nader (1998), Shapiro (1998), Teinowitz (1998), Wilson (1999), and Sloan and Trogdon (2004).

marketing regulations affect the efficient mix of production inputs as well as marketing inputs.[20] In the sections that follow, data envelopment analysis (DEA) is used to estimate allocative, technical, and overall cost efficiency scores from 1963 to 2002, and an inter-temporal approach is used to compare efficiency scores before and during each advertising restriction.[21]

---

[20] The limited research on advertising by medium has focused on the issues of substitutability among media and scale economies of advertising. Bresnahan (1984) estimates the demand equation for different advertising media and investigates the substitutability between retail services and advertising for six consumer goods industries. Silk et al. (2002) estimate the market demand for media by national advertisers and find that there is weak substitutability and complementarity among media. On the other hand, Seldon et al. (2000) estimate the cost of advertising in various media that are needed to generate sales using a translog cost model. They find a high degree of substitutability among television, radio, and print advertising in the U.S. brewing industry. If input substitutability is high in the U.S. cigarette industry, then the Broadcast Advertising Ban would not be excessively costly to producers, since they could mitigate the effect of the Ban by reallocating expenditures from broadcast to unrestricted media.

[21] For a discussion of other welfare issues involving advertising restrictions in the U.S. cigarette market, see Farr et al. (2001) and Iwasaki et al. (forthcoming).

3.2 Production and Marketing Technology

In a consumer goods industry like cigarettes where both production and marketing are important to sales, we consider a technology with both components, as in Bresnahan (1984), Seldon et al. (2000), Färe et al. (2004), and Vardanyan and Tremblay (forthcoming). Unlike their work, however, production and marketing costs are not assumed to be separable. This produces the following full (production and marketing) cost function:

(3.1) $$C(y, w_p, w_m) = \min_x \left\{ w_p x_p + w_m x_m : x_p \text{ and } x_m \text{ can produce } y \right\},$$

where y is output, x_p is a vector of production inputs, w_p is a vector of production input prices, x_m is a vector on marketing inputs, and w_m is a vector of marketing input prices. It says that a minimized cost is obtained by choosing an input vector x, where x is the vector of all production and marketing inputs and $x'=(x'_p, x'_m)$, that minimizes a sum of production cost and marketing cost for a given level of output, input price and technology.

An alternative way to describe technology is with an input requirement set. This is defined as follows:

(3.2) $$L(y) = \{x: x \text{ can produce } y\},$$

The input requirement set $L(y)$ consists of all input vectors that can produce the output vector y. It provides a convenient way of describing efficiency and *in*efficiency. To illustrate, consider the technology described in Figure 3.1 with two inputs, x_1 and x_2, where input combination A is used to produce y. Production is technically *in*efficient, since fewer inputs could be used to produce the same output. If we follow Farrell (1957) and contract toward the origin (0), then a technical efficiency can be measured by the distance 0B/0A. This is sometimes called a technical efficiency score. Production becomes more technically efficient as A approaches B and is technically efficient when the efficiency score equals 1. If the iso-cost is represented by the line CD, then the economically efficient point is D. By contracting toward the origin once again, allocative efficiency can be measured by the distance 0C/0B. Production becomes more allocatively efficient as B approaches C and is allocatively efficient when the score equals 1. Likewise, overall cost efficiency is measured as 0C/0A (or 0B/0A times 0C/0B). When overall efficiency is reached, points A, B, C, and D coincide, and all efficiency scores equal 1.

In our application, it is more convenient to use *in*efficiency scores, which derive directly from efficiency scores. In the example in Figure 3.1, technical inefficiency is measured as 1 – 0B/0A or AB/0A; allocative inefficiency equals 1 – 0C/0B or BC/0A; overall cost inefficiency equals 1 – 0C/0A or AC/0A. In this case, overall efficiency is reached when all inefficiency scores equal zero.

To estimate the frontier of the input requirement set and inefficiency scores, we use non-parametric frontier estimator. An advantage of these approaches is that it avoids imposing a specific functional form on technology. There are two methods used widely. One of them is a Free Disposable Hull (FDH) estimator, which relies on the free-disposability assumption on the technology. The other is a DEA estimator, which requires additional assumption of convexity. We use DEA as it has a superior asymptotic property.[22] In DEA, an activity analysis model is used as a framework. Activity analysis model is a framework for modeling technology and is the foundation for the DEA model as formulated in Charnes, Cooper, and Rhodes (1978). It defines the input requirement set for each observation τ, given t = 1, 2, 3… T observations and n = 1, 2, 3, …, N inputs, as follows:

$$
\begin{aligned}
L(y_\tau) = \{(x_1,\dots,x_N) : & \textstyle\sum_{t=1}^{T} z_t y_t \ge y_\tau, \\
& \textstyle\sum_{t=1}^{T} z_t x_{tn} \le x_n,\ n = 1,\dots,N \\
& z_t \ge 0, \qquad t = 1,\dots,T \\
& \textstyle\sum_{t=1}^{T} z_t = 1\}
\end{aligned}
\tag{3.3}
$$

where the τ subscript represents a particular time period. We impose strong disposability of output and inputs by the inequality in the first and second lines respectively. The strong input disposability

[22] A shortcoming of DEA is that a statistical property of the estimator is unknown for the multi-output and –input case. In the case of single input and output technology, a density function is known up to some unknown parameters.

modeled above says that the output does not decrease if any or all feasible inputs are increased.[23] The third and forth lines are conditions for the intensity variables, z_t, $t=1, \ldots, T$, where each t value is defined for each observation. The derived value of this variable can be interpreted as the extent to which a particular observation is involved in the production of potential outputs.[24] The restriction on this variable, $\sum^T z_t=1$, allows the model to exhibit variable returns to scale. That is, returns to scale are not constrained and the technology can exhibit increasing, constant, and decreasing returns to scale.[25]

To measure technical efficiency, we apply the Farrell (1957) index with respect to the following linear programming model,

$$
\begin{aligned}
F_i(y_\tau, x^\tau) = \min \lambda : \quad & \sum\nolimits_{t=1}^{T} z_t y_t \geq y_\tau, \\
& \sum\nolimits_{t=1}^{T} z_t x_{tn} \leq \lambda x_{n,\tau}, \; n = 1, \ldots, N \\
& z_t \geq 0, \qquad\qquad t = 1, \ldots, T \\
& \sum\nolimits_{t=1}^{T} z_t = 1.
\end{aligned} \tag{3.4}
$$

where λ is an *in*efficiency index. With this notation, x^τ represents a vector with N inputs at time period τ. In the example in Figure 3.1, this measure equals 0B/0A, the minimum distance from the observed input combination (point A) to the frontier of the input requirement set (point B), divided by the distance 0A. The technical inefficiency score equals 1 minus this score.

To determine overall cost efficiency, we must compute the minimum total cost of producing a given output for each τ. This is derived from the following model,

---

[23] If this is strictly equal, then it imposes the weak disposability of inputs and output and, in this case, output can be increased only when all feasible inputs increase proportionally.

[24] For more discussion, see Färe and Grosskopf (1996).

[25] By restricting the intensity vector to sum to unity, the programming problem constructs a closed polytype, hence allowing the technology to exhibit various returns to scale. A more restrictive non-increasing returns to scale technology can be obtained by imposing concavity on the production function such that $\sum^T z_t \leq 1$.

$$
\text{(3.5)} \quad
\begin{aligned}
C^*(\tau) = C^*(y_\tau, w) = \min_{x^\tau} & \sum_{n=1}^{N} w_n x_n \\
s.t. \quad & \sum_{t=1}^{T} z_t y_t \geq y_\tau, \\
& \sum_{t=1}^{T} z_t x_{tn} \leq x_n,\ n = 1, \ldots, N \\
& z_t \geq 0, \qquad t = 1, \ldots, T \\
& \sum_{t=1}^{T} z_t = 1.
\end{aligned}
$$

The solution to this linear programming problem gives us the lowest cost of producing an output given input prices at time τ, $C^*(\tau)$. Overall cost efficiency is defined as the ratio of minimized cost to observed cost.

$$
\text{(3.6)} \quad C^*(t) / \sum_{n=1}^{N} w_{tn} x_{tn} \qquad t = 1, \ldots, T \,.
$$

Hence, the observed cost is minimized when this ratio equals 1. Overall cost efficiency requires both allocative and technical efficiency.

A measure of allocative inefficiency can be obtained by comparing observed media share and optimal media share. This is described below:

$$
\text{(3.7)} \quad w_{tn} x_{tn} / \sum_{n=1}^{N} w_{tn} x_{tn} - w_{tn} x_{tn}^* / C^*(t) \qquad \begin{matrix} n = 1, \ldots, N \\ t = 1, \ldots, T \end{matrix} \,.
$$

x^*_{tn} denotes the level of input n at time t that minimizes cost. The second ratio tells us the industry at time t is minimizing the cost to yield sales y_t. These differences indicate if the industry spends the cost minimizing input combination. This measure equals zero when the industry optimally allocates its expenditure in each media (i.e., there is no allocative inefficiency). It is positive when the industry spends too much on that input category and negative when expenditures are too little.

Finally, returns to scale are not constrained and can exhibit increasing, constant, or decreasing returns. Assuming moderate scale economies and a reasonable degree of competition, the industry would be scale efficient if overall scale exhibited constant returns. With increasing (decreasing) returns, scale efficiency would improve if there were fewer (more) firms and each firm produced more (less) output.

We use a method developed by Färe et al. (1985) to estimate scale efficiency. Let $TE^{t,VRS}$ denote a technical efficiency score at time t evaluated under the assumption of variable returns to scale. If we drop the last equation in (3.4), the technology is said to exhibit constant returns to scale. The solution to the modified problem is the efficiency index, denoted by $TE^{t,CRS}$. $TE^{t,CRS}$ is the product of "pure" technical efficiency and scale efficiency, where scale efficiency for period t is defined as $SE^{k} = TE^{k,CRS} / TE^{k,VRS}$. It represents the proportion of inputs that can be further reduced after pure technical inefficiency is eliminated if scale adjustments are possible. It has a value of less than or equal to one. If it has a value equal to one, the industry at time t is operating at the constant returns to scale region. If it is less than one, then the industry at time t is scale *in*efficient and there is potential input saving through the adjustment of its operational scale. Whether the scale inefficient input choice at time t should be downsizing or expanding depends on its current operating region.

To determine the current operating region, first, an efficiency index must be computed when the technology exhibits a Non-Increasing Returns to scale (NIRS). This can be done by relaxing the assumption on weight variables in (3.4) to be less than or equal to one. The solution to this problem is denoted by $TE^{t,NIRS}$. $TE^{t,NIRS}$ is then compared with $TE^{t,VRS}$. If $TE^{t,NIRS} = TE^{t,VRS}$, then the scale inefficient period *t* is operating in the decreasing returns region and would be benefited by downsizing. On the other hand, if $TE^{t,NIRS} < TE^{t,VRS}$, then the scale inefficient period t is operating in the increasing returns region and should expand its production.

Figure 3.2 illustrates this measure in terms of a production function with a single input. If the linear programming representation of the production function is the frontier ABCDE and actual production occurs at point B, then production takes place in the region of increasing returns. Constant return occurs at point C. At point B, the Färe et al. measure of scale inefficiency is $x_F/x_B \leq 1$, with less scale inefficiency as this measure gets closer to 1.

3.3 Results

Annual observations from 1963 through 2002 are used to estimate the production-marketing technology for the U.S. cigarette industry. Production inputs include labor, capital, and materials. Marketing inputs include broadcast (television and radio), print, and other advertising messages. Variable definitions, data, sources, and measurement issues are discussed in Appendix A. Figure 3.3 plots the quantity of advertising messages in broadcast, print, and other media during the sample period. These data reveal that broadcast was the dominant medium before the ban. After the ban, the number of print and other advertising messages rose dramatically. By the early 1980s, the other category, primarily promotional allowances to retailers and discount coupons to consumers, became the dominant form of marketing.[26]

Given the extent of government regulation and the history of marketing activity in the U.S. cigarette industry, we focus our discussion on the four regimes delineated in Figure 3.3. The first regime, 1963-1970, is the unregulated period when broadcast advertising was dominant. The second period, 1971-1986, is the period immediately following the broadcast advertising ban. In 1986, the U.S. Surgeon General's Report concluded that second-hand smoke causes health problems in non-smokers, an announcement that soon led to stricter state and local clean indoor air laws [Chaloupka (1992), Chaloupka and Saffer (1992), and Ross and Chaloupka (2004)]. The 1987-1998 delineation is of further interest because it represents a time when the industry invested heavily in promotional marketing activity and precedes the National Tobacco Settlement. The final period, 1999-2002, marks the Settlement era.

Figure 3.4 plots the pattern of per-capita cigarette smoking over time. It shows that per-capita smoking reached a peak just before the U.S. Surgeon General's report in 1964, the first official recognition that cigarette smoking causes lung cancer. The per-capita smoking rate rose slightly after the Broadcast Advertising Ban but has shown a general pattern of decline since reaching a peak in 1963.

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[26] Promotional activity includes the sponsorship of local public events and the distribution of discount coupons and free samples.

Turning to our DEA estimation, we begin by investigating how allocative inefficiency changes over the sample period. DEA estimates of allocative inefficiency scores for each production and marketing input are displayed in Figure 3.5. Recall that allocative efficiency is reached when the inefficiency score equals zero, and a positive (negative) score implied that too much (little) of the input is being used. Inefficiency scores for the production inputs (labor, materials, and capital) are all close to zero and appear to be unaffected by advertising restrictions. This would occur if the production and marketing divisions of cigarette producers operate independently, as assumed in previous studies. Alternatively, the marketing inefficiency scores are more volatile and suggest that the Broadcast Advertising Ban had an important influence on allocative inefficiency in advertising. Before the Ban, the industry invested too heavily in broadcast advertising and too little in print and other advertising media. After the Ban, the broadcast inefficiency score fell to zero in every subsequent period, providing strong evidence that the optimal amount of broadcast advertising at the industry level is zero. This supports the view that cigarette producers faced a prisoners' dilemma in broadcast advertising and that the Ban facilitated coordination. Although somewhat less striking, the figures also suggest that the National Tobacco Settlement led to lower allocative inefficiency in advertising.

To formally evaluate the effect of advertising restrictions on allocative inefficiency, we compare mean score estimates between pre- and post-regulatory regimes. Table 3.1 lists the means and standard deviations of the allocative inefficiency estimates for the entire sample and for each regime. Because the process generating production and marketing inefficiency may be different, we evaluate them separately as well as jointly.[27] The data verify that mean allocative-inefficiency scores fell dramatically after the Ban and the Settlement. For example, mean inefficiency scores in

[27] The marketing allocative-inefficiency score is measured as the sum of the absolute values of the allocative-inefficiency scores for broadcast, print, and other advertising. The production allocative-inefficiency score is calculated as the sum of the absolute values of the allocative-efficiency scores for labor, materials, and capital. We also measured them as the sum of squared values of individual scores, and the conclusions of our research are unaffected by this alternative way of measuring allocative inefficiency in marketing and production.

marketing and production fell by more than 90 percent after the Ban and over 86 percent after the Settlement.

Table 3.2 summarizes the results of Analysis Of Variance (ANOVA) tests for differences in mean inefficiency scores. Each test of the hypothesis that the means are the same in all four regimes is rejected at the 1 percent significance level for marketing, production, and both inefficiency scores. Because these hypotheses are rejected in every case, we proceed with tests across regulatory regimes 1-2 and 3-4. The results confirm that the Ban and the Settlement led to a significant decrease in all allocative inefficiency categories. The settlement led to a decrease in allocative inefficiency, but the difference in means in production is insignificant. This suggests that it takes a substantial marketing restriction to affect allocative efficiency in production. Given that inefficiency scores are truncated at zero and an ANOVA test is valid only for random variables that are normally distributed, we also perform non-parametric tests for distributional differences across regulatory regimes [Wackerly et al. (2001, pp. 724-730)]. This test assumes that the two populations have continuous frequency distributions. The test is preceded as follows. First, the results of the two samples are combined and arranged in order of increasing size and given a rank number. In cases where equal results occur, the mean of the available rank numbers is assigned. Second, calculate the rank sum R of the smaller sample is calculated. Third, letting N denote the size of the combined samples and n denote the size of the smaller sample, following is calculated

$$R^* = n(N+1) - R$$

The values R and R^* are compared with critical values that are provided in Natrella (1963). If either R or R^* are less than the critical value, the null hypothesis of the same mean would be rejected.

The results in Table 3.2 indicate that the in each case the distributions of the allocative-inefficiency scores are significantly different at the 1 percent level of significance for the two regulatory regimes. These results support the conclusion that cigarette producers invested too heavily in broadcast advertising before the Ban and that marketing restrictions led to less allocative inefficiency in the U.S. cigarette industry.

Next, we investigate the effect of marketing restrictions on technical and overall cost inefficiency. Because advertising typically accounts for less than 20 percent of total costs before and after the Ban, we expect marketing restrictions to have a relatively small effect on technical and overall cost inefficiency. Table 3.3 reports the DEA estimates of mean inefficiency scores and standard deviations, as well as the results from ANOVA and non-parametric tests for differences across marketing regimes. In terms of technical inefficiency, marketing restrictions had a small and insignificant effect. On the other hand, overall cost inefficiency, which includes both technical and allocative inefficiency, fell substantially after each marketing restriction. The mean overall cost inefficiency score fell by about 48 percent after the Ban and by over 77 percent after the Settlement.[28] In addition, distributions and mean inefficiency scores across regimes are significantly different in most cases. These results indicate that marketing restrictions lowered overall cost inefficiency by lowering allocative inefficiency and suggest that coordination effects dominated any inefficiency resulting from LeChatelier effects in the U.S. cigarette industry.

The mean and standard deviation of scale estimates for the whole sample and for each regime are reported in Table 3.3. For presentation purposes, we define scale efficiency (SE) to equal the Färe et al. measure minus 1 and take the absolute value of this measure when there are scale economies. In this case, SE = 0 for constant returns, SE > 0 for increasing returns, and SE < 0 for decreasing returns. Our estimate of scale efficiency over the sample period is about 0.02, implying slight scale economies. In both the ANOVA and non-parametric tests, the null hypothesis

---

[28] Estimates of overall inefficiency after the Settlement should be interpreted with caution, however, since the Settlement required financial payments to state governments as well as tighter marketing restrictions. Financial stress caused by these payments may have induced belt tightening and may partially explain the lower inefficiency scores after the Settlement. Another concern is the dramatic increase in cigarette prices after the Settlement. Efficiency comparisons are invalid if an advertising restriction substantially affects cigarette prices. This is not a problem for regimes 1 and 2, as the real price (1982 dollars) per cigarette was about 4.6 cents in regime 1 and about 4.34 cents in regime 2. However, real prices rose gradually in regime 3 and then dramatically in regime 4. The mean real price was 5.76 cents in regime 3 and 9.18 in regime 4. This price increase may have been caused by the National Tobacco Settlement or may have been a rational price response to the decline in the number of potential cigarette smokers as suggested by the dynamic pricing models for addictive commodities (Becker et al., 1994, and Iwasaki et al., forthcoming). In any case, these price increases would bias our inefficiency scores upward in regime 4. Thus, our estimates tend to underestimate the efficiency improvement caused by the Settlement.

of equal means across regimes is accepted. On the other hand, if we closely look at mean values in each regime, the scale economy is diminished after the Broadcast Advertising Ban in 1971 (Regime 2) and the National Tobacco Settlement in 1998 (Regime 4). The results may reflect the effect of which the industry cuts back advertising expenditures on specific marketing media after the regulations.

To further analyze the effect of marketing restrictions on inefficiency in the cigarette industry, we develop a model of inefficiency and perform regression analysis. One problem with this line of research is that there is little room for inefficiency in the neoclassical model of the firm. Unregulated firms that maximize profits will always use the cost minimizing input combination in the long run. In this framework, inefficiency at the firm level could result only from government regulation or unexpected demand and cost shocks. This need not be the case at the industry level, however, as firms need not minimize industry costs when there are coordination problems in marketing and economies of scale in production.

For completeness, we estimate individual regression models for technical inefficiency, overall cost inefficiency, and allocative inefficiency in marketing, production, and both marketing and production. To control for unexpected demand and cost shocks, independent variables include the annual percentage change in per-capita consumption (%Δpcy) and the percentage change in total cost (%ΔCost). To evaluate the effect of marketing restrictions, we use dummy variables to control for the Ban and the Settlement: D_{71} represents the ban, which equals 1 from 1971 on and 0 otherwise; D_{99} represents the Settlement, which equals 1 from 1999 on and 0 otherwise. Let θ_t^j denote inefficiency scores for marketing cost allocation ($j=AE_M$), production cost allocation ($j=AE_P$), marketing and production cost allocation ($j=AE$), technical ($j=TE$), and overall cost ($j=OE$). Then, we have five regression equations of the following form:

$$\theta_t^j = \beta_0^j + \beta_1^j \%\Delta pcq + \beta_2^j \%\Delta Cost + \beta_3^j D_{71} + \beta_4^j D_{99} + \varepsilon_t^j .$$

If a positive demand shock is unanticipated, it would lessen financial pressure, which could lead to greater managerial slack and inefficiency, while an unexpected increase in costs would increase financial pressure and discourage inefficiency. The Ban and Settlement would reduce inefficiency if the coordination effect dominates and would increase inefficiency if the LeChatelier effect dominates.

One concern is that our dependent variables of inefficiency scores are truncated at zero and, therefore, are not normally distributed. To account for truncation, we use a maximum-likelihood estimation technique discussed in Leopold and Wilson (2004). The likelihood function to be estimated is

$$L = \prod_{t=1}^{T} \frac{1}{\sigma_\varepsilon} \varphi\left(\frac{\theta_t - z_t\beta}{\sigma_\varepsilon}\right)\left[1 - \Phi\left(\frac{z_i\beta}{\sigma_\varepsilon}\right)\right]^{-1}$$

where $\varphi(\cdot)$ and $\Phi(\cdot)$ represent the standard normal density and distribution functions, respectively. This resembles the likelihood for regression models with normal errors that are neither censored nor truncated, except for the term in the square brackets. Division by this term is necessary to re-scale the normal density $\varphi(\cdot)$ so that it integrates to unity after truncation.

Truncated regression estimates are provided in Table 3.4. In many cases, the effects of %Δpcy and %ΔCost are insignificant, suggesting that demand and cost shocks were generally anticipated and had little effect on inefficiency. This is consistent with the analysis of means in which the Ban had a negative and significant effect on allocative inefficiency in each of three cases. In addition, the Settlement had a negative effect on allocative inefficiency, but the results are significant only in the case of production. In any case, parameter estimates indicate that the Ban and the Settlement had their greatest effect on allocative inefficiency in marketing.

As a final point, note that a marketing restriction will increase profits if the coordination effect dominates the LeChatelier effect. The effect on profits may be difficult to detect, however, because marketing expenses are a small proportion of total cost and because LeChatelier and coordination effects may cancel each other out. In any case, when we measure profits by the price-cost margin, the figures at the top of Table 3.5 indicate that average profit rates are 13 percent higher in regime 2 than regime 1, and are 7 percent higher in regime 4 than regime 3. Although the difference in means is insignificant for regime 1 and 2 (the Ban) and for regimes 3 and 4 (the Settlement), non-parametric tests indicate that both the Ban and the Settlement lead to significant differences in the distribution of profit rates. These results are generally consistent with the hypothesis that marketing restrictions facilitated collusion and increased industry profits.[29]

[29] An important concern with a comparison across regimes is that more than an advertising restriction would influence profit rates over time. In any case, the regression analysis by Farr et al. (2001) that controls for demand and cost shocks supports the hypothesis that the Ban led to higher profits in the U.S. cigarette industry. The ceteris paribus assumption is less likely to be a concern when investigating inefficiency scores, however. For example, if all firms are profit maximizers and all demand and cost changes are anticipated, then only government regulations affect efficiency. Thus, a comparison of mean inefficiency scores across regimes is appropriate, since the ceteris paribus assumption would hold.

3.4 Concluding Remarks

We evaluate the effect of marketing restrictions on inefficiency in the U.S. cigarette industry. In an imperfectly competitive market like cigarettes, the effect of a regulation on a strategic variable such as advertising is uncertain. On the one hand, the LeChatelier Principle indicates that when a regulation effectively limits the ability of firms to substitute cheaper for more expensive inputs, productivity will fall. On the other hand, restrictions that limit a combative strategy like advertising may facilitate coordination, resulting in an improvement in marketing efficiency and an increase in industry profits.

We use annual data and DEA to estimate the degree of allocative, technical, and overall cost inefficiency for the U.S. cigarette industry. A comparison of inefficiency estimates before and after a regulation allows us to analyze the efficiency effects of the Broadcast Advertising Ban and the National Tobacco Settlement. The empirical evidence shows that the Ban and the Settlement had a negative effect on inefficiency. This suggests that coordination effects dominated LeChatelier effects.

The strongest evidence involves the effect of the Ban on allocative inefficiency. All of the empirical evidence supports the hypothesis that the Broadcast Advertising Ban led to less allocative inefficiency in marketing. First, DEA evidence indicates that the efficient amount of broadcast advertising for the industry as a whole is zero. Yet, before the Ban cigarette producers allocated about 70 percent of their marketing expenditures on broadcast advertising. Second, truncated regression analysis indicates that the Ban had a negative and significant effect on allocative inefficiency. Finally, regression analysis indicates that the Ban had a positive significant effect on profits Taken as a whole, this provides convincing evidence that cigarette producers faced a prisoners' dilemma in broadcast advertising and that the Ban facilitated coordination.

Table 3.1
Estimates of Mean Allocative Inefficiency Scores

	All (1963-2002)	**Regime 1 (1963-1970)**	**Regime 2 (1971-1986)**	**Regime 3 (1987-1998)**	**Regime 4 (1999-2002)**
Marketing	0.0669	0.1640	0.0118	0.0936	0.0128
	(0.0724)	(0.0179)	(9.6E-05)	(.0049)	(0.0255)
Production	0.0056	0.0118	0.0054	0.0036	0.0002
	(0.0045)	(0.0028)	(0.0036)	(.0020)	(0.0004)
Marketing & Production	0.0725	0.1758	0.0172	0.0972	0.0130
	(0.0752)	(0.0203)	(0.0131)	(0.0722)	(0.0260)

Note: Inefficiency scores range from 0 to positive infinity, with a higher score implying greater inefficiency. A zero score means there is no allocative inefficiency. Numbers in parenthesis are standard error.

Table 3.2
Test for Differences in Mean Allocative Inefficiency Scores

Regime	**Allocative Inefficiency In:**	**One-Way ANOVA Test F-Statistic**	**P-value**
All Four Regimes:			
	Marketing	28.849*	1.1E-09
	Production	18.973*	1.5E-07
	Marketing & Production	28.842*	1.1E-09
Regime 1 vs. Regime 2			
	Marketing	7.8161*	0.0004
	Production	2.7939***	0.0541
	Marketing & Production	7.8602*	0.0004
Regime 3 vs. Regime 4			
	Marketing	3.9217**	0.0161
	Production	1.3305	0.2796
	Marketing & Production	3.9355**	0.0158

Regime	**Allocative Inefficiency In:**	**Mann-Whitney-Wilcoxon Test Smallest Rank Sum**
Regime 1 vs. Regime 2		
	Marketing	36*
	Production	46*
	Marketing & Production	36*
Regime 3 vs. Regime 4		
	Marketing	16**
	Production	11*
	Marketing & Production	17**

Note: The ANOVA test is a one-tailed test, and the Mann-Whitney-Wilcoxon test is two-tailed.
*Statistically significant at 1%.
**Statistically significant at 5%.
***Statistically significant at 10%.

Table 3.3
Mean Technical and Overall Cost Inefficiency and Tests for Differences in Inefficiency Scores

	Means (Standard Deviations)				
	All (1963-2002)	**Regime 1 (1963-1970)**	**Regime 2 (1971-1986)**	**Regime 3 (1987-1998)**	**Regime 4 (1999-2002)**
Technical	0.0175 (0.034)	0.0000 (NA)	0.0319 (0.002)	0.0158 (0.0007)	0.0000 (NA)
Overall	0.1538 (0.1252)	0.1988 (0.0016)	0.1031 (0.0088)	0.2258 (0.025)	0.0500 (0.01)
Scale	0.0185 (0.0432)	0.0275 (0.0396)	0.0063 (0.0253)	0.0350 (0.0637)	0.0000 (NA)

Regime	**Type of Inefficiency:**	**One-Way ANOVA Test F-Statistic**	**P-value**
All Four Regimes:			
	Technical	2.2189	0.1027
	Overall Cost	4.3526**	0.0103
	Scale	1.4138	0.2546
Regime 1 vs. Regime 2	Overall Cost	0.4130	0.7446
Regime 3 vs. Regime 4	Overall Cost	2.4826**	0.0765

Regime	**Type of Inefficiency:**	**Mann-Whitney-Wilcoxon Test Smallest Rank Sum**
Regime 1 vs. Regime 2		
	Technical	28*
	Overall Cost	56***
	Scale	99
Regime 3 vs. Regime 4		
	Technical	26
	Overall Cost	16***
	Scale	42

Note: The ANOVA test is a one-tailed test, and the Mann-Whitney-Wilcoxon test is two-tailed. Numbers in parenthesis are standard errors.
*Statistically significant at 1%.
**Statistically significant at 5%.
***Statistically significant at 10%.

Table 3.4
Truncated Regression Results for Allocative, Technical and Overall Cost Inefficiency

Independent Variable	Dependent Variable				
	Allocative Inefficiency in			Technical	Overall Cost
	Marketing	Production	Mkt. & Prod.		
Constant	0.2000*	0.011*	0.1853**	0.4469	0.0964
	(0.0563)	(0.0018)	(0.0834)	(0.4152)	(0.3486)
%Δpcq	-0.8585	-0.0296	-0.9896	-5.6959**	-2.0554
	(0.6675)	(0.0308)	(0.6751)	(2.5361)	(1.9317)
%ΔCost	-1.9418***	0.0255	-1.1278	3.0023**	-1.3940
	(1.1662)	(0.0181)	(0.7735)	(1.5224)	(1.5575)
D_{71}	-0.1693**	-0.0099*	-0.2047***	-0.1497	-0.0894
	(0.0723)	(0.0024)	(1.9475)	(0.1546)	(0.3465)
D_{99}	-0.1021	-0.0155**	-0.1023	-0.2363	0.2919
	(0.067)	(0.0068)	(0.0812)	(0.2005)	(0.2471)

Note: Numbers in parenthesis are standard errors.
*Statistically significant at 1% by the two-tailed test.
**Statistically significant at 5% by the two-tailed test.
***Statistically significant at 10% by the two-tailed test.

Table 3.5
Mean Price-Cost Margin and Tests for Differences in Inefficiency Scores

Means (Standard Deviations)				
All (1963-2002)	**Regime 1 (1963-1970)**	**Regime 2 (1971-1986)**	**Regime 3 (1987-1998)**	**Regime 4 (1999-2002)**
0.0175 (0.034)	0.5265 (0.0513)	0.5962 (0.0263)	0.6342 (0.0362)	0.6807 (0.0225)

Regime	**One-Way ANOVA Test F-Statistic**	**P-value**
All Four Regimes	22.366*	2.4E-08
Regime 1 vs. Regime 2	2.1987	0.1050
Regime 3 vs. Regime 4	1.7398	0.1762

Regime	**Mann-Whitney-Wilcoxon Test Smallest Rank Sum**
Regime 1 vs. Regime 2	53**
Regime 3 vs. Regime 4	16*

Note: The ANOVA test is a one-tailed test, and the Mann-Whitney-Wilcoxon test is two-tailed.
Numbers in parenthesis are standard errors.
*Statistically significant at 1%.
**Statistically significant at 5%.
***Statistically significant at 10%.

Figure 3.1
Cost Efficiency Decomposition

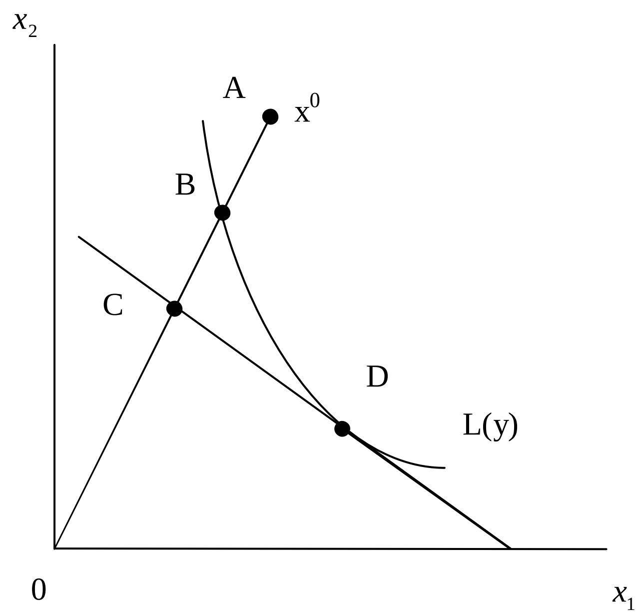


Figure 3.2
Scale Efficiency

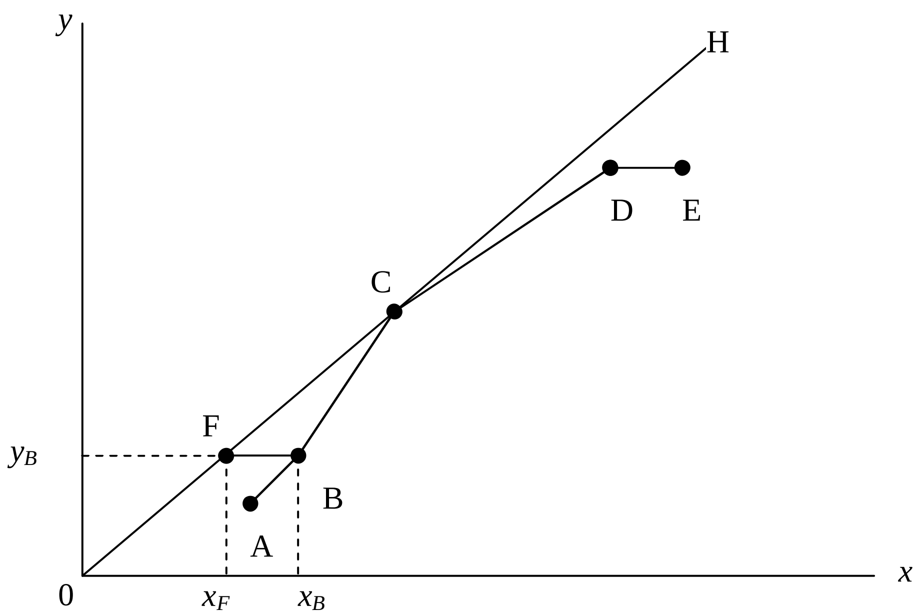


Figure 3.3
Broadcast, Print and Other Advertising Messages

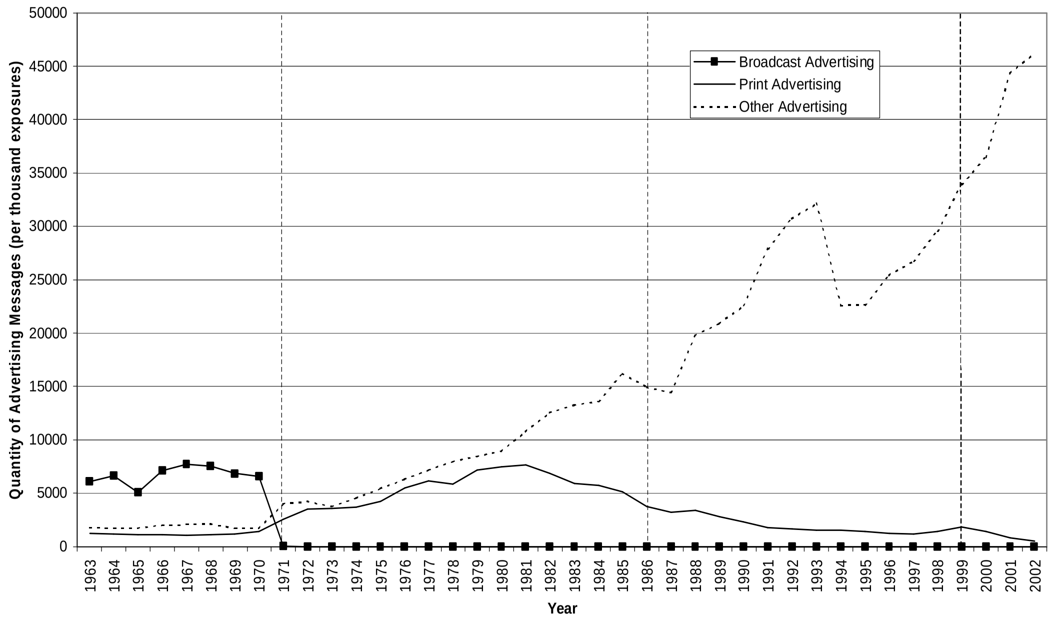


Figure 3.4
Per-Capita Cigarette Consumption

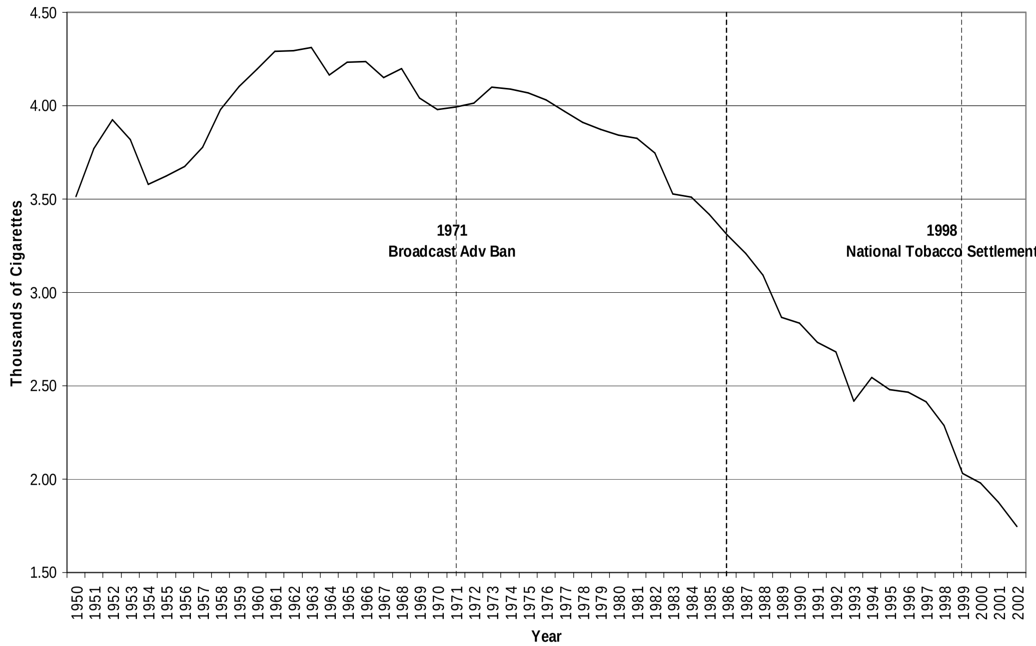
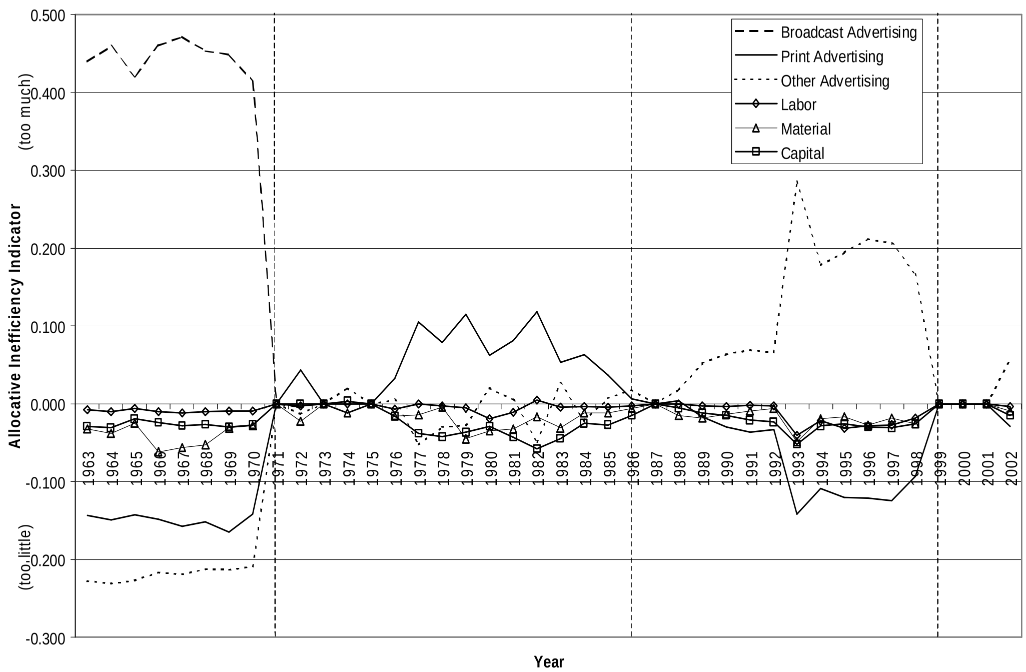


Figure 3.5
Allocative Inefficiency Indicator (efficient when indicator = 0)



Chapter 4

Determinants of Profitability, Advertising, and Concentration: Evidence from the U.S. Brewing Industry

4.1 Introduction

Early Structure-Conduct-Performance (SCP) studies are concerned with a relationship between market structure and market performance. Early empirical models that use this framework use inter industry observations and regresses a performance measure on various measures of industry structure using ordinary least squares. Strickland and Weiss (1976) were the first to introduce the idea of solving a simultaneous equation model arguing that concentration, price-cost margins and advertising are endogenous. A system wide approach that successfully accommodates endogeneity has been popularized by Martin (1978), and extended by Geroski et al. (1987) and Jeong and Masson (2003).[30]

While these approaches are successful in finding empirical regularities across industries, economists often criticize SCP studies for being descriptive rather than analytic, as they generally fail to explain the nature of causality in detail. In these studies, equations explaining profitability, advertising and concentration are constructed independently from each other and are designed to accommodate data from different industries where firms may behave differently. This makes it difficult to interpret the regression results.

To circumvent this problem, one option is to focus on a particular industry with a consistent set of institutional details [Bagwell (2005)]. Another option is to obtain implications from a game-theoretic model as Sutton (1992) emphasizes. This study uses both approaches. We focus on the history of the market structure, strategy and performance of a single industry over fifty years so as to incorporate industry specific information. This approach allows us to incorporate a game theoretic model that is likely to give more consistent results.

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[30] See Schmalensee (1989) for a survey of their literatures.

We chose the U.S. brewing industry as a case study. The U.S. brewing industry has experienced a dramatic change in market structure over the last fifty years. These changes provide a natural laboratory for studying the determinants of market structure and performance. Four variables are of particular interest: the Hirfindahl-Hirshman Index (*HHI*) of industry concentration; efficient market share (*ES*), which is defined as minimum efficient scale (*MES*) divided by total U.S. beer consumption; an advertising-to-sales ratio (*AS*); and a price-cost margin (*PCM*).

Figure 4.1 plots the *HHI* over time.[31] Since 1950, the *HHI* has risen consistently. To understand its cause, notice that the *HHI* accounts for both number of firms and their size heterogeneity. In the brewing industry, size heterogeneity across firms has risen continuously over time, which pushes up the *HHI*. On the other hand, number of firms has increased due to an evolution of specialty brewers, which has a negative impact on the *HHI*. In 1950, there were 350 brewers, all of which were traditional macro brewers with a firm size variance of 0.0001 among the largest hundred brewers 0.0001.[32] In 2004, there were 1522 brewers in operation of which only 22 were macro brewers and 1500 were specialty brewers. By 2004, the variance in firm size increased to 0.0029. The substantial increase in the variance is largely due to changes in market structure of traditional macro brewers; where a decrease in firm number and an increase in size heterogeneity have been observed. The combined market share of the largest three macro brewers in 1950 was only 17.3 percent [Tremblay et al. (2005)]. The market became national in scope by the mid-1960s, and the market share of the largest three grew to 28.4 percent. In 1965, there were still 126 macro brewers in operation. The market structure continued to change until the largest three macro

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[31] The *HHI* is defined as a sum of squared market share of the largest hundred brewers in the U.S., in which the market size is measured with domestic consumption (i.e., it includes both domestically produced beer and imported beer).

[32] U.S. beer industry is generally divided into three segments. The first of these includes macro brewers, which brew traditional lager style beer and are generally national in scope. The second segment includes brew pubs, restaurant breweries, and microbreweries. Because they started out with very small facilities, they are initially defined as brewers producing less than 15,000 barrels per year. However, some are producing in excess of 20,000 barrel per year now and no longer fit in the conventional definition. Because they brew European-style beer, they started being called specialty brewers to distinguish them from the imported beer of the same style. The firms in the third segment include international brewers which sell beer in the U.S.

brewers, Anheuser-Busch, Coors and Millers, came to dominate much of the market. In 2004, a combined market share of the dominant three reached 80 percent.

There are two views regarding the cause of rising concentration in the U.S. brewing industry. The first of these is technological progress that increased *MES*. When *MES* grows faster than market size, *ES*, the market share needed to reach MES and defines a cost minimizing market share, will increase. In this view, the observed rising concentration is a natural consequence of the goal of reaching efficient scale. An alternative view stresses the role of escalating advertising expenditures among major brewers. An escalation of advertising expenditures increases *HHI* if there are scale economies in advertising or if advertising is an endogenous sunk cost [Sutton (1992)].

The U.S. brewing industry has experienced a substantial increase in *ES* (Figure 4.2). Notice that the *HHI* and *ES* have similar trends. While it is arguable that the rise in *ES* played a major role in the rise in the *HHI*, other factors may also play a role. In an international comparison of beer industries in France, Germany, Italy, Japan, and the United Kingdom, Sutton (1992) finds that the U.S. industry is the most concentrated market despite of its relatively large geographical market.

The U.S. market is where advertising spending is the highest, and Sutton argues that this may explain the high concentration in the U.S. brewing industry. Figure 4.3 plots *AS*, 1950-2004. To understand the potential positive causality from *AS* to *HHI*, one needs to realize advertising is a strategic variable. To investigate how the degree of competition affects AS and HHI, it is convenient to divide the data into several regimes. In Figure 4.3, three peaks can be identified – in 1964, 1988 and 2002 – and a period around each peak can be considered as an advertising regime.[33] Sutton (1992) and Tremblay and Tremblay (2005) observe that advertising wars often start with a

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[33] Tremblay and Tremblay (2005) identify five regimes. The first regime (1950-1964) is characterized by a high advertising intensity and coincides with a time when television advertising became an important marketing medium. Advertising intensity declined in the second regime (1965-1974) and rose again in the third regime (1975-1986). The third regime occurred when Miller increased its market share through a massive advertising campaign. Advertising expenditure declined again during 1987-1995, which is identified as the fourth regime and characterized by an expansion of Coors. Since 1996 (the fifth regime), advertising expenditures came from three national brewers have started to rise again.

strengthening of market share by one or more second-tier brewers through an effective advertising campaign. Subsequently, the first tier brewers responded with their own escalation in advertising. Brewers that can keep up with the increase in advertising expand their market share, while those who are left behind decline in size and/or exit. The net effect of an advertising war is therefore an increase in concentration. [34]

One might argue which factor plays a major role in determining current market structure of the U.S. brewing industry. However, there is a possibility that the two factors interact and both play a role [Sutton (1992)].[35] That is, an evolution of a fierce advertising competition can set firms in a position where high scale production is more profitable (higher *MES*), and vice versa. Furthermore, in this framework, an increase in advertising effectiveness can trigger fierce advertising competition. Hence, it is arguable that a rise in *ES* that began in the early-1960s was triggered by a high advertising intensity during the mid-1950s through the mid-1960s, a period when television came into wide use.

Figure 4.1 is a plot of the *PCM* against time.[36] Like *AS* it fluctuates unpredictably. Simple static oligopoly models, such as Cournot, suggest that a high *HHI* causes a high *PCM*. On the other hand, Demsetz (1973) argues that higher profit may emerge due to a superior efficiency of larger firms.[37] However a predicted positive correlation between the *HHI* and the *PCM* is not clear from a

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[34] Advertising may accumulate an intangible asset in the form of goodwill. A firm with higher goodwill is able to price higher than ones with lower goodwill. Also, with persuasive advertising, a firm can differentiate its product from rivals' and avoid a price competition. This will lead to a higher price. The Dorfman-Steiner condition suggests that advertising intensity equals a product of *PCM* and advertising elasticity of price. With either theory, we would expect positive relation of *AS* to *PCM*, while it is unclear from a comparison of Figure 4.3 and Figure 4.4.

[35] In Sutton's framework, the U.S. brewing industry is a typical example of complex case where both *MES* (exogenous sunk cost) and advertising (endogenous sunk cost) play an important role in determining a market structure.

[36] The *PCM* is defined as a difference between total revenue and total variable cost, which is a sum of material cost and labor cost, divided by total revenue. It excludes advertising expenditures from calculation.

[37] In empirical study, Greer (1970) shows how the profitability of U.S. brewers varied across size class and there is a clear evidence of high profit for the largest ones.

casual comparison of the data (see Figure 4.1 and Figure 4.4).[38] If we look at Figure 4.5 which plots market shares of the largest three firms, a sharp rise in the *PCM* in the 1980s coincides with the rapid expansion of market share of the largest firm, which consistent with Demsetz's (1973) efficiency argument.

A casual investigation of the U.S. brewing industry data suggests that there is a potential two-way causality among key variables. Causes of rising concentration are likely to be both technical and strategical. Given previous literatures, we propose two approaches and two corresponding models. The first model is consistent with the traditional approach as in Martin (1978). The second model is motivated by a game theoretic approach as in Sutton (1992). In the second approach, a system of three equations will be redefined as the first order conditions of the oligopoly profit maximizing problem. The two systems will be estimated with nonlinear three-stage least squares.

In the next section, we review a system of three equations used in Martin (1978), Geroski et al. (1987) and Jeong and Masson (2003) and modify it based on the characteristics of the U.S. brewing industry. Next, we look at Sutton's game theoretic approach to market structure and his predictions, which guide a development of the second model. Finally, the two systems are estimated with nonlinear least squares. Both approaches generate robust results. First, advertising intensity and minimum efficient scale play major roles in increasing concentration, findings consistent with Sutton's prediction. Second, there is a potential coordination of behavior at a very high level of concentration.

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[38] Tremblay and Tremblay (2005) note that interpreting a national measure of concentration in brewing needs a care as a market for beer is regional until early 1960s. This may explain a declining trend in the mid 1960s when the market was in a transition from a regional to a national market.

4.2 System One: Martin's Approach to SCP

Profit Equation

Martin (1978) defines a profit equation as follows:

(4.1)
$$PCM_t = f^1(C_t, BE_t, \varepsilon_{QPt}) + e_t^{PCM1}$$

where *PCM* is an industry's price-cost margin; *C* is one or more variables that measure an ease of collusion; *BE* is one or more variables that affect the entry condition; ε_{QP} contains variables that affect the price elasticity of demand and e^{PCM1} is an error term.

To measure an effect of *C*, Martin (1978) and others use a four-firm concentration ratio. In the present study, we adopt the *HHI*. We prefer the *HHI* as it accounts for both a number and size distribution of firms. The relation of the *HHI* to the *PCM* may be positive for three reasons: First, the use of a trigger strategy to support collusive behavior is more likely as the number of competitors falls; Second, if more efficient firms gain market share, industry profit will be positively associated with the *HHI*; Third, if we define the *PCM* as a first order condition of the oligopoly model, assuming all firms are equal in size, it is an increasing function of the *HHI* [Waterson (1986)].

Entry conditions (*BE*) are often measured with *ES*, *AS*, and capital-to-sales ratio (*KS*). Strickland and Weiss (1976) argue that *ES* and *KS* create scale barriers, while *AS* raises the potential scale barrier as well as a product differentiation barrier. Higher values of these variables imply higher barriers to entry and increase concentration. On the other hand, Martin (2002) argues that *KS* should be included if the PCM is used to measure profitability as it ignores the fixed cost of capital expenditures. If the *PCM* ignores advertising expenditure as well, *AS* needs to be included to control for a normal rate of return on goodwill assets [Carlton and Perloff (1991, p266)]. As a result, *AS* and *KS* play a dual role: a control for normal rate of return and a measure of entry condition.

We use the ratio of the observed number to the optimal number of macro brewers to measure the disadvantages of having many inefficient firms [Martin (1977) and Caves et al. (1979)]. The optimal number of brewers is computed by dividing the observed total output of macro brewers by *MES*. This measures the number of firms that would exist if all firms produced at *MES* (i.e., the cost minimized number of firms). An expected relation between them is negative as competition is tougher when there are the more firms in the market than the optimal level. This variable also reflects the toughness of competition in a war of attrition game [Bulow and Klemperer (1999)]. In the story of the war of attrition game, N firms compete for N^* prizes where $N>N^*$. Competition would be tougher as the fewer positions become available compared to the number of firms currently in operation. In the U.S. brewing industry, N^* decreased rapidly over time as *MES* grew faster than the size of market. The ratio of N to N^* measures a degree of which too many firms exist in the market. Hence, it also reflects a degree of cost disadvantage for firms operating under a minimum efficient scale. As the industry leaders expanded their market share over time, the smaller scale firms were put under greater financial stress.

In previous studies, an effect of ε_{QP} is controlled with an import-to-sales ratio and the market growth rate (*GR*).[39] They are popular demand variables largely due to data availability. In addition, because of their generality, they are suitable for inter-industry study where various demand conditions across industries need to be controlled for. However, alternative variables may be preferred when one studies a time series of a single industry. In our case of the U.S. brewing industry, we chose a proportion of the population aged between 18 and 44 (*DEM*).[40] Tremblay and Tremblay (2005) find that consumers in this age group are likely to drink more beer than consumers in other age groups. If we assume that consumer's taste for beer is fairly stable over time, the greater population of age 18-44 implies a greater potential market.[41] We expect higher demand elasticity for the higher *DEM*.[42]

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[39] Pagoulatos (1986) finds that the price elasticity is in part influenced by competitive behavior in the industry. The variables measuring competitive behavior are advertising expenditures, industry concentration, the stage of production, the existence of protection from domestic and foreign entry, and the extent of new product introduction in a particular market.

[40] We also consider a market share of domestic specialty beer and import beer. Import beer and specialty beer are considered as close substitute of each other while they are only a partial substitute of domestic macro beer (Tremblay and Tremblay, 2005, p104).

[41] While a DEM captures a potential market size, a conventional measure of *GR* is based on the realization of the market size.

Advertising Equation

Martin (1978) defines an advertising equation as follows,

(4.2) $$AS_t = g^1(PCM_t, \varepsilon_{QAt}, CR_t, CR_t^2) + e_t^{AS1}$$

Martin's advertising equation is rooted in a Dorfman-Steiner type model of advertising [Schmalensee (1972, pp. 20-43)]. The Dorfman-Steiner condition suggests that *AS* will equal the product of the *PCM* and the advertising elasticity of demand (ε_{QA}). This suggests that the relationships between *PCM* and *AS* and between ε_{QA} and *AS* are positive.

Strickland and Weiss (1976) argue that advertising intensity is expected to increase with concentration as the price elasticity of demand is lower in a more concentrated industry. In addition, Greer (1971) hypothesizes that advertising may decrease at a very high level of concentration. In this case, the relation of concentration to advertising intensity would be an inverted U. To test this hypothesis, previous studies include both *CR* and CR^2 and the expected signs are negative and positive, respectively.

In previous studies, variables that explain the effect of ε_{QA} are left out of the model. They are assumed to be controlled for with the import-to-sales ratio and *GR*, which are the controls for ε_{QP}. We consider the variables that are more closely related to advertising effectiveness. We introduced two variables. They are a percent of households with TV sets (*TV*) and a ratio of the total advertising spending in the U.S. to disposable personal income (*NAS*). Note that *AS* reflects the effectiveness of advertising. That is, *AS* rises when sales grows slower than advertising expenditure. Alternatively *AS* decreases when sales grows faster than advertising expenditure. As the households with TV sets increases, advertising may become more effective in reaching consumers. As a result, the same level of advertising induces more sales and *AS* tends to decrease. On the other hand, an increase in *NAS* may diminish the effectiveness of beer advertising. As the

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[42] Other demand variables we considered are the price of beer and per capita disposable income. However, Tremblay and Tremblay (2005) find that these variables have a very limited impact on beer consumption. This may be due to the addictive nature of beer consumption.

advertising volume at the national level increases, relative advertising volume of the beer is smaller and beer advertising becomes less effective at increasing sales.

Concentration Equation

Martin (1979) argues that observed concentration, CR_t, will approach its long-run equilibrium level, CR^*, at a rate of λ:

(4.3a) $$CR_t - CR_{t-1} = \lambda(CR^* - CR_{t-1})$$

where Martin also argues that

(4.3b) $$\lambda = h^{\lambda 1}(PCM_{t-1}, BE)$$

(4.3c) $$CR^* = h^{CR1}(BE_t, GR_t)$$

and λ is a speed of convergence. This is called a partial adjustment model. It implies that the actual change of concentration from the last period (i.e., CR_t-CR_{t-1}) is only a fraction of the difference that is necessary to reach the long-run level (i.e., CR^*-CR_{t-1}) [Maddala (1977, p.142)]. If λ is less than one, the dynamic adjustment process is stable and CR_t converges to it's long-run level over time. Martin argues that λ depends on a lagged *PCM* and *BE* (equation (4.3b)). Higher current profit induces greater entry next period and reduces concentration.

Long-run concentration in (4.3c) depends upon *BE* and *GR*. *GR* is included in order to test Gaskin's (1971) hypothesis. He argues that when the market is growing, incumbents may price higher which allows more entry. On the other hand, Baumol and Fischer (1978) emphasize the role of productive efficiency. In this argument, observed high concentration is a natural outcome of profit maximizing behavior because the efficient number of firms increases as the market expands relative to *MES*. Both hypotheses predict a negative relation of market growth to concentration, and are empirically indistinguishable.

4.3 System Two: Game Theoretic Approach to SCP

The main contribution of an empirical SCP study is that it realizes links between the market performance, conduct, and structure. However, while endogeneity is a central issue, the connection between endogenous variables is not supported analytically. We felt that the system should derive from an optimization problem. To this end, we derive three equations as a solution to an oligopoly profit maximizing problem. This approach may be more appropriate here, because we focus on a single industry's performance as opposed to an inter-industry study as performed previous studies.

Sutton takes a game theoretic approach and shows what happens to the market structure and competition as market size grows. To this end, Sutton distinguishes between exogenous and endogenous sunk cost and emphasizes an importance of the toughness of price competition. Here, "toughness" means the competitiveness of price and non-price competition.

In his analysis of endogenous sunk costs, Sutton identifies a three-stage game where firms decide whether to enter a market with a given level of set-up costs in the first stage of the game and compete in advertising and quantity in later stages. In this setting, Sutton identifies the sub-game perfect Nash equilibrium solution in quantity, advertising and resulting market structure.[43] Compared to the SCP approach, Sutton's game theoretic approach identifies the two-way link between structure and conduct.[44] Our model is based on a two-stage game but otherwise closely follows Sutton. In the second stage of the game, the first order conditions generate our version of the profit equation and advertising equation. The entry decision at the first stage will be based on a set-up cost at, and the expected profitability after, the entry. Consequently, we obtain a system of three equations that explain profit, advertising intensity and concentration ratio as in previous studies, but they are derived from the game theoretic framework.

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[43] Sutton uses an experience of the U.S. brewing industry to illustrate a complex case where both set-up cost and advertising outlays play a prominent role in determining market structure.

[44] As Bresnahan (1992) pointed out the availability of endogenous sunk cost strategies and the toughness of price competition do not just determine equilibrium industry structure, but they also determine industry performance given structure. That is, Sutton's prediction can be empirically tested as a simultaneous equation problem.

4.3.1 Quantity Game and Profit Equation

Let us define the market inverse demand function as:

(4.4) $$P = P(Q, A)$$

where $Q = q_i + q_{-i}$ is total market output, $A = a_i + a_{-i}$ is total market advertising messages, q_i is output produced by firm *i*, q_{-i} is output produced by all firms except firm *i*, a_i is advertising messages sent by firm *i* and a_{-i} is advertising messages sent by all firms except firm *i*.

Total revenue for firm *i* is $TR_i = P(Q, A)\, q_i$. First, we consider the first order condition of quantity choice. This equals:

(4.5) $$P(Q,A) + q_i \left\{ \frac{dP}{dQ}\left(1 + \frac{dq_{-i}}{dq_i}\right) + \frac{dP}{dA}\frac{da_{-i}}{dq_i} \right\} - MC_i = 0$$

where MC_i is marginal cost of firm *i*. Let us define the conjectural elasticities of quantity with respect to output and advertising as,

$$\alpha_i = \frac{q_i}{q_{-i}}\frac{dq_{-i}}{dq_i}$$

$$\beta_i = \frac{q_i}{a_{-i}}\frac{da_{-i}}{dq_i}$$

Then, equation (4.5) becomes:

(4.6) $$P(Q,A) + q_i \left\{ \frac{dP}{dQ}\left(1 + \frac{q_{-i}}{q_i}\alpha_i\right) + \frac{dP}{dA}\beta_i \frac{a_{-i}}{q_i} \right\} - MC_i = 0$$

Rearranging the equation we find,

(4.7) $$\frac{P(\bullet) - MC}{P} = \frac{1}{\varepsilon_{QP}}\left\{(1-\alpha_i)s_i + \alpha_i\right\} - \varepsilon_{PA}\frac{\beta_i a_{-i}}{A}$$

where

$$\varepsilon_{QP} = -\frac{\partial Q}{\partial P}\frac{P}{Q}$$

$$\varepsilon_{PA} = \frac{\partial P}{\partial A}\frac{A}{P}$$

and

$$s_i = \frac{q_i}{Q}$$

are price elasticity of demand, advertising elasticity of inverse demand, and firm *i*'s market share respectively. Let us define the total cost function for firm *i* as

(4.8) $$TC_i = p_L q_L + p_M q_M + \lambda_i^K P^K K_i + \lambda_i^A P^A a_i$$

where p_L, p_M, P_K, and P_A are price of labor, material, capital and advertising and q_L, q_M, K, and a are quantity of labor, material, capital and advertising messages respectively. λ^K and λ^A are rental cost of capital and advertising and they are the sum of the earned rate of return and a rate of depreciation [Carlton and Perloff (2004, p248) and Martin (2002, p160)]. That is, $\lambda^K=r+\delta^K$ and $\lambda^A=r+\delta^A$ where r is the competitive rate of return, δ^K is the rate of physical depreciation of capital, and δ^A is the rate of depreciation of goodwill stock. Since the entry decision has already been made, the set-up cost does not enter the total cost function in this stage of play.

If returns to scale are constant, then

(4.9) $$MC_i = AC_i = \frac{p_L q_L + p_M q_M + \lambda_i^K P^K K_i + \lambda_i^A P^A a_i}{q_i}$$

Where AC_i is the average cost of firm *i*. Substituting (4.9) into (4.7), we obtain the Price-Cost Margin equation for firm *i* (PCM_i),

(4.10) $$\frac{P(\bullet)q_i - p_L q_L - p_M q_M}{Pq_i} = \frac{1}{\varepsilon_{QP}}\{(1-\alpha_i)s_i + \alpha_i\} - \varepsilon_{PA}\frac{\beta_i a_{-i}}{A} + \lambda_i^K \frac{P^K K_i}{Pq_i} + \lambda_i^A \frac{P^A a_i}{Pq_i}$$

Here, we treat the labor and material costs as variable costs and the capital and advertising assets as fixed costs. To find the *PCM* equation for the industry, let us assume that $\alpha_i=\alpha_{-i}$ for all *i* in the long-run equilibrium. Then we multiply equation (4.10) through by s_i for each *i*, and add it up for all *i* firms in the industry. We now obtain the *PCM* equation at the industry level,

(4.11 a) $$\frac{P(\bullet)Q - p_L q_L - p_M q_M}{PQ} = \frac{1}{\varepsilon_{QP}}\{(1-\alpha)HHI + \alpha\} - \varepsilon_{PA}\frac{\beta a}{A} + \lambda^K \frac{P^K K}{PQ} + \lambda^A \frac{P^A A}{PQ}$$

or

(4.11 b) $$PCM^O = \frac{1}{\varepsilon_{QP}}\{(1-\alpha)HHI + \alpha\} + \lambda^K KS + \lambda^A AS - \varepsilon_{PA}\frac{\beta a}{A}$$

where superscript *O* indicates that this is a first order condition of an oligopoly competition. λ^K and λ^A are the weighted average rental costs of capital and advertising, respectively [Martin (2002, p.151)]. That is,

$$\lambda^K = \sum_i \lambda_i^K (\frac{K_i}{K})$$

$$\lambda^A = \sum_i \lambda_i^A (\frac{a_i}{A})$$

As discussed earlier, the *HHI*, *KS*, and *AS* should have a positive effect on *PCM*. Recall that coefficients on *KS* and *AS* are rental costs of capital and goodwill respectively. The difference between the rental cost of capital and that of advertising is a difference of depreciation rates.

If firms behave as a cartel, the monopoly's first order condition will be observed and equation (4.11) becomes:

(4.12) $$PCM^M = \frac{1}{\varepsilon_{QP}} + \lambda^K KS + \lambda^A AS$$

where superscript *M* indicates that this is a first order condition of a monopoly. The *HHI* becomes irrelevant in determining the *PCM*. If there are changes in the degree of competitiveness, parameter values will change and the model can be written as:

(4.13) $$PCM_t = f^2(HHI_t, \frac{1}{\varepsilon_{QP\ t}}, AS_t, KS_t, -\varepsilon_{PA} \mid \Phi) + u_t^{PCM\,2}$$

where Φ is a vector of parameters that depends on the degree of competition. This includes conjectural elasticity parameters α and β.

4.3.2 Advertising Game and Advertising Equation

Next, we consider a firm's decision to advertise. The firm's problem is:

$$\max_{a_i} \Pi_i = P_i(Q, A)q_i - TC(q_i, a_i)$$

where *TC* = *TVC* + *TFC* and *TVC* and *TFC* are total variable cost and total fixed costs.

The first order condition for advertising implies that

(4.14) $$\frac{\partial TR(Q, A)}{\partial a_i} = \frac{\partial TC(q_i, a_i)}{\partial a_i}$$

Notice that the advertising may increase the demand and increase the production cost,

$$\frac{\partial TC(Q,A)}{\partial a_i} = \frac{\partial TC}{\partial q_i}\frac{\partial q_i}{\partial a_i} + \frac{\partial TC}{\partial a_i}$$

Let us define $MC_i = \partial TC/\partial q_i$. Then,

$$\frac{\partial TC(Q,A)}{\partial a_i} = MC_i \frac{\partial q_i}{\partial a_i} + \frac{\partial TC}{\partial a_i}$$

Using equation (4.7) and (4.13), we find,

(4.15) $$\left[\frac{\partial P(Q,A)}{\partial A}(1+\frac{\partial a_{-i}}{\partial a_i}) + \frac{\partial P(Q,A)}{\partial Q}(\frac{\partial q_i}{\partial a_i} + \frac{\partial q_{-i}}{\partial a_i})\right] q_i + P(Q,A)\frac{\partial q_i}{\partial a_i} = MC_i \frac{\partial q_i}{\partial a_i} + \lambda_i^A P^A$$

Let us define the conjectural elasticity parameters of advertising as

$$\gamma_i = \frac{\partial a_{-i}}{\partial a_i}\frac{a_i}{a_{-i}}$$

$$\eta_i = \frac{\partial q_{-i}}{\partial a_i}\frac{a_i}{q_{-i}}$$

So,

(4.16) $$q_i\left[\frac{\partial P(Q,A)}{\partial A}(1+\gamma_i\frac{a_{-i}}{a_i}) + \frac{\partial P(Q,A)}{\partial Q}(\frac{\partial q_i}{\partial a_i} + \eta_i\frac{q_{-i}}{a_i})\right] + (P - MC_i)\frac{\partial q_i}{\partial a_i} - \lambda_i^A P^A = 0$$

Assuming all firm have identical costs,

(4.17) $$MC = MC_i \quad \forall i$$

Rearranging the equation,

(4.18) $$\left[\frac{\partial P(Q,A)}{\partial A}(1+\gamma_i\frac{a_{-i}}{a_i}) + \frac{\partial P(Q,A)}{\partial Q}(\frac{\partial q_i}{\partial a_i} + \eta_i\frac{q_{-i}}{a_i})\right] + (P - MC)\frac{\partial q_i}{\partial a_i} - \lambda_i^A \frac{P^A a_i}{Pq_i}\frac{Pq_i}{a_i} = 0$$

Let us denote firm *i*'s advertising expenditure to revenue ratio as,

$$AS_i = \frac{P^A a_i}{Pq_i}$$

Rearranging the equation (4.18), we obtain the advertising equation at the firm level.

(4.19) $$AS_i = \frac{1}{\lambda_i^A}\left[\left\{\frac{\partial P(Q,A)}{\partial A}\frac{a_i}{P}(1+\gamma_i\frac{a_{-i}}{a_i}) + \frac{\partial P(Q,A)}{\partial Q}\frac{a_i}{P}(\varepsilon_{qa}^i\frac{q_i}{a_i} + \eta_i\frac{q_{-i}}{a_i})\right\} + (\frac{P - MC_i}{P})\varepsilon_{qa}^i\right]$$

where

$$\varepsilon_{qa}^{i} = \frac{\partial q_i}{\partial a_i} \frac{a_i}{q_i}$$

which is firm *i*'s advertising elasticity of demand. This condition implies that the advertising intensity of firm *i* depends on the rental cost of advertising (λ_i^A) and firm *i*'s advertising elasticity of demand (ε_{qa}) and conjectural elasticity parameters of advertising (γ_i and η_i).

Assuming $\gamma_i = \gamma_{-i} = \gamma$, $\eta_i = \eta_{-i} = \eta$, $\varepsilon_{qa}^{i} = \varepsilon_{qa}^{-i} = \varepsilon_{qa}$ and $a_i = a_{-i} = a$ in equilibrium for all *i*, and aggregating over all *i* firms in the industry, we have an advertising equation for the industry,

$$\text{(4.20)} \quad AS^C = \frac{1}{\lambda^A}\left[\left\{\varepsilon_{PA}(1+\gamma) - \frac{1}{\varepsilon_{QP}}(\varepsilon_{qa} + \eta)\right\} + PCM\,\varepsilon_{qa}\right]$$

Now, we are interested in how a change in competition affects the outcome. If firms agree to collude, equation (4.20) will be replaced with the monopoly's profit maximization condition.

$$\text{(4.21)} \quad AS^M = \frac{1}{\lambda^A}\left[\varepsilon_{PA} + PCM\,\varepsilon_{QA}\right]$$

In general, an advertising equation can be defined as:

$$\text{(4.22)} \quad AS_t = g^2(PCM_t, \varepsilon_{PA}, -\frac{\varepsilon_{qa}}{\varepsilon_{QP}}, \lambda^A \mid \Phi) + u_t^{AS}$$

where Φ is a vector of parameters that depend on the toughness of competition.

Equation (4.22) implies that *AS* increases when advertising has a positive impact on the demand price and the advertised firm's product (i.e., $\varepsilon_{QA}>0$, $\varepsilon_{PA}>0$ and $\varepsilon_{qa}>0$). On the other hand, firms respond to a high rental cost of advertising (i.e., high λ^A) by lowering the advertising intensity. As in the previous model, we use *TV* and *NAS* to measure the effect of changes in ε_{PA} and ε_{qa} on *AS*. We also include *HHI* as it influences the ε_{PA}, ε_{qa}, and ε_{QP}. We expect high values of ε_{PA} and ε_{qa} for a high *HHI*. On the other hand, a high *HHI* causes ε_{QP} to decrease. HHI may cause AS to increase or decrease.

Φ includes elasticity parameters γ and η, the impact of these on *AS* may change depending on the type of competition and the type of advertising. When advertising is combative, a conjectural advertising derivative is likely to be positive (i.e., $\gamma>0$ and $\eta>0$) and will lead to an increase in *AS*.[45] If advertising is more constructive, conjectural advertising elasticities may be negative (i.e., $\gamma<0$ and $\eta<0$).

4.3.3 Entry Decision and Concentration Equation

A firm's entry decision depends on the expected profit after entry and the set-up cost that the firm has to pay upon the entry. Assuming a symmetric cost structure, firms enter the market so long as the following condition holds

$$\frac{E(\Pi(Q^*, A^*))}{N} \geq \sigma \tag{4.23}$$

where $\Pi(Q^*, A^*)$ is an industry's long-run profit and σ is a set-up cost that a firm has to pay when it enters the market. This condition implies that firms enter the market so long as the expected profit after entry exceeds the set-up cost. Equation (4.23) can be rewritten as

$$\frac{1}{N} \geq \frac{\sigma}{E(\Pi(Q^*, A^*))} \tag{4.24}$$

The left hand side of the equation (4.24) coincides with the *HHI* when firms are equal in size. This implies that market concentration is determined by the expected long-run profit, which depends on a long-run output and advertising level, and on expected set-up costs. There is more entry when an expected profit is large relative to the set-up costs. Let us denote an expected value of *HHI* as $HHI^*(\sigma, \Pi)$. Equality holds in equilibrium:

$$E\left[\frac{\sigma}{\Pi(Q^*, A^*)}\right] = HHI^*(\sigma, \Pi) \tag{4.25}$$

Let us assume that expectations are adoptive; that is,

$$HHI_t^* - HHI_{t-1}^* = \theta(HHI_t - HHI_{t-1}^*) \quad \text{where } 0<\theta<1 \tag{4.26}$$

or

$$HHI_t^* = \theta HHI_t + (1-\theta) HHI_{t-1}^* \tag{4.27}$$

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[45] In the U.S. cigarette industry, Iwasaki and Tremblay (2006) found that TV advertising is more likely to be combative.

Equation (4.27) suggests that the expected level of *HHI* is a weighted average of the present level of *HHI* and the previous expected level of *HHI* (or HHI_{t-1}^{*}). A smaller value of θ means that the present level of *HHI* receives a smaller weight, implying a greater uncertainty about the future. Since $0<\theta<1$, if an observed value is greater than the expected value, a firm revises its expectation upward. In the opposite case, it revises the expectation downward. In either case, the revision is only a fraction of the most recent year's expectation error (i.e., $HHI_{t-1}-HHI_{t-1}^{*}$).

Because *HHI* is a function of the expected market structure HHI^{*}, we can write

(4.28) $$HHI_t = \beta HHI_t^{*}$$

Since the HHI^{*} is a weighted average of all present and previous values of *HHI*,

(4.29) $$HHI_t = \beta\theta \sum_{s=0}^{\infty} (1-\theta)^{s} HHI_{t-s}^{*} + \varepsilon_t = \frac{\beta\theta}{1-wL} HHI_t^{*} + \varepsilon_t$$

where $w=1-\theta$ and L is a lag operator [Pindyck and Rubinfeld (1976, pp. 214-216)]. Rearranging equation (4.29), we obtain

(4.30) $$HHI_t = \theta\beta HHI_t^{*} + (1-\theta) HHI_{t-1} + u_t \qquad \text{where } u_t = \varepsilon_t - (1-\theta)\varepsilon_{t-1}$$

In general, the concentration equation can be defined as:

(4.31 a) $$HHI_t = \theta h^2 (\Pi(Q^{*}, A^{*})_{t-1}, \sigma_{t-1} \mid \Phi) + (1-\theta) HHI_{t-1} + u_t^{HHI2}$$

where

$$h^2 (\Pi(Q^{*}, A^{*})_{t-1}, \sigma_{t-1} \mid \Phi) = \beta HHI_t^{*}$$

We condition $h^2(\cdot)$ on Φ because the type of competition may affect expected profitability for the new entrant. In the empirical application, a set-up cost (σ) is measured with *ES*, which coincides with a reciprocal of the exogenous sunk cost measure used in Sutton (1992).[46] As for the profit, notice that industry profit is $\Pi (Q,, A)=TR-TC$. Equation (4.10) and (4.12) imply that, profit can be expressed as

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[46] This is an empirical test of Sutton's prediction on the relation between concentration and market size: whether the concentration decline as the market size expands. He runs OLS regression of the form: $CR=a+b\ln(s/\sigma)$ where s is a market size and σ is a set up cost. The expected signs of b are negative for the exogenous sunk cost industry and the zero for the endogenous sunk cost industry.

$$\Pi = PCM - KS - AS = h(\frac{1}{\varepsilon_{QP}}, -\varepsilon_{PA})$$

Therefore *Π* can measured with *PCM*, *AS*, *KS*, ε_{QP} and ε_{PA},

(4.31 b) $$HHI_t = \theta h^2(PCM_{t-1}, KS_{t-1}, AS_{t-1}, ES_{t-1}, \frac{1}{\varepsilon_{QP}}, \varepsilon_{PA} \mid \Phi) + (1-\theta)HHI_{t-1} + u_t^{HHI2}$$

The HHI is expected to fall with the PCM and rises with KS, AS, and ES.

4.4 Empirical Models and Results

System One

System one consists of equations (4.1), (4.2) and (4.3) that we discussed in section 4.2.1. They are

(4.1) $$PCM_t = f^1(C_t, BE_t, \varepsilon_{QPt}) + e_t^{PCM1}$$

(4.2) $$AS_t = g^1(PCM_t, \varepsilon_{QAt}, CR_t, CR_t^2) + e_t^{AS1}$$

(4.3 a) $$CR_t - CR_{t-1} = \lambda(CR^* - CR_{t-1}) + e_t^{CR1}$$

where

(4.3 b) $$\lambda_t = h^{\lambda 1}(PCM_{t-1}, BE)$$

(4.3 c) $$CR^* = h^{CR1}(BE_t, GR_t)$$

Since the empirical version of the concentration equation is based on a "partial adjustment model", λ should be interpreted as a rate of convergence toward an equilibrium concentration. Martin (1978) argues that λ should be a function of the *PCM* and *BE*. Geroski et al. (1987) and Juong and Masson (2003) assume the following functional form for λ:

(4.32) $$\lambda_t = \mu_0[PCM_{t-1} - PCM_t^{LR}(BE)]^2$$

It is specified as a convex function of the distance between the *PCM* and the steady state price-cost margin, PCM^{LR}, which is a function of barriers to entry, *BE*. The relationship between λ and $PCM\text{-}PCM^{LR}$ is expected to be convex because faster entry/exit is likely when *PCM* is substantially above or below PCM^{LR}.

When $PCM<PCM^{LR}$, firms will exit. The exit rate is expected to be slower as the distance between the *PCM* and the PCM^{LR} falls. Alternatively, when $PCM>PCM^{LR}$, there is an entry. During our sample period from 1950 through 2004, there is no entry of macro brewers, only exit, in the U.S. beer industry, implying that $CR<CR^*$ and $PCM<PCM^{LR}$ and *CR* is increasing.

We measure *BE* with *AS* and *ES*. PCM^{LR} is expected to rise with *AS* and *ES* and it can be expressed as an upward shift of a PCM^{LR} curve. If current concentration is below the long-run level, an upward shift in PCM^{LR} will cause λ to rise by increasing CR^*. Consequently, we specify our regression equations as follows:

(4.33a) $$PCM_t = a_0 + a_1 HHI_t + a_2 AS_t + a_3 KS_t + a_4 DEM_t + a_5 N / N_t^* + e_t^{PCM1}$$

(4.33b) $$AS_t = b_0 + b_1 HHI_t + b_3 HHI_t^2 + b_4 PCM + b_5 TV_t + b_6 NAS_t + e_t^{AS1}$$

(4.33c) $$HHI_t = \lambda_t [(c_0 + c_1 AS_t + c_3 ES_t + c_4 GR_t) - HHI_{t-1}] + HHI_{t-1} + e_t^{HHI1}$$

where

(4.33d) $$\lambda_t = (d_0 + d_1 PCM_{t-1} + d_2 AS_t + d_3 ES_t)^2$$

In equation (4.33c), the term in the round bracket represents a long-run concentration CR^* which is expected to rise with *AS* and *ES*. A specification of λ is described in equation (4.33d). As implied by equation (4.32), $PCM^{LR}=-(d_0+d_2AS+d_3ES)$ and PCM^{LR} is increasing in *AS* and *ES*. Because λ equals a square of the distance between *PCM* and PCM^{LR}, an estimate of d_1 should have an opposite sign to d_2 and d_3.

Variables are defined in Table 4.1, which also lists their means and standard errors. In this system, the endogenous variables are HHI_t, PCM_t, and AS_t. Predetermined variables are HHI_{t-1} and PCM_{t-1}, and strict exogenous variables are KS_t, ES_t, DEM_t, N/N^*_t, TV_t, NAS_t,,and GR_t.

The system of equations (4.33) is estimated using a non-linear least squares. Because of HHI_{t-1} in equation (4.33 c), we suspect an autocorrelation problem. To test for an AR (1) process for e_t^{HHI1}, we assume that $e_t^{HHI1}=\rho e_{t-1}^{HHI1}+u_t$ where u_t is nonautocorrelated error term.[47] We replace equation (4.33 c) with

$$HHI_t = \lambda_t [(c_0 + c_1 AS_t + c_3 ES_t + c_4 DEM_t) - HHI_{t-1}] + HHI_{t-1} + \rho e_{t-1}^{HHI1} + u_t$$

where λ is as defined in (4.33d). If ρ is less than zero and significant, there is an AR (1) process and estimates are corrected for an AR (1). If ρ is insignificant, the null hypothesis of no AR (1) process is accepted and equation (4.33) is preferred. We found ρ to be insignificant. In terms of the estimation method, we estimate the system using a nonlinear two-stage least squares (NL2SLS) and nonlinear three-stage least squares (NL3SLS). In either case, we use current values and lagged values of the strictly exogenous variables as instruments. Because estimates of NL2SLS and

[47] e_{t-1} is defined as a difference between lagged values of the right-hand side and the left-hand side of the regression equation.

NL3SLS are similar, we test a null hypothesis where both NL2SLS and NL3SLS are the consistent estimators against the alternative where only NL3SLS estimator is consistent using Hausman test. The test rejects the null. Therefore we proceed with estimating (4.33) with NL3SLS. Our estimates are follows

(4.34a) $$PCM_t = 0.902 + 0.321HHI_t + 4.279AS_t + 0.047KS_t - 0.016N / N^*_t - 1.633DEM_t$$
(5.406) (3.271) (6.721) (2.085) (2.956) (4.189)

(4.34b) $$AS_t = -0.105 + 0.431HHI_t - 1.357HHI_t^2 + 0.205PCM - 0.020TV_t + 1.694NAS_t$$
(4.436) (3.586) (3.800) (6.568) (2.439) (3.549)

(4.34c) $$HHI_t = \lambda_t[(-0.305 + 5.671AS_t + 3.654ES_t - 0.478GR_t) - HHI_{t-1}] + HHI_{t-1}$$
(1.328) (1.464) (3.119) (0.401)

where

(4.34d) $$\lambda_t = (-0.269 + 2.744PCM_t - 23.6AS_t - 5.300ES_t)^2$$
(0.476) (3.089) (2.752) (1.669)

where *t*-statistics are in parenthesis. In equation (4.34a), we find a positive and significant impact of the *HHI* on the *PCM*, a finding consistent with the prediction of several models of imperfect competition. Advertising intensity (*AS*) and capital intensity (*KS*) have a positive and significant impact on the *PCM*, implying that high fixed costs create an entry barrier. Also, they are the controls for a normal rate of return on a fixed asset. A war-of-attrition parameter (N/N^*) has an expected sign of negative and is significant. We include *DEM* to control for an effect of changes in demand elasticity. The results indicate that a higher value of *DEM* raises the demand elasticity which tends to diminish market power and the *PCM*.

In equation (4.33 b), coefficients on *HHI* and HHI^2 are positive and negative, respectively. This indicates the effect of concentration on advertising intensity is an inverted *U*-shape and there is potential collusive behavior at the high level of concentration, a finding consistent with Greer (1971). *AS* also increases with the *PCM*. This is consistent with the Dorfman-Steiner condition. *TV* and *NAS* are included to capture the effects of changes in advertising elasticity of demand on the industry's advertising effectiveness. As expected, the spread of TV sets among consumers makes advertising campaign more effective, allowing firms to lower advertising intensity. On the other hand, growing advertising spending from other industries appears to lower the effectiveness of beer advertising as indicated by the positive and significant coefficient estimate on *NAS*.

In equation (4.33c), the inside bracketed term represents the steady state concentration level. According to our estimates, the primary determinant of steady-state concentration is technological. The coefficient estimate on *ES* (efficient market share) is positive and significant, while the coefficient estimate on *AS* is positive but insignificant. Negative coefficient estimate on *GR* is consistent with both Gaskins's (1971) model of dynamic limit pricing and Baumol and Fischer's (1978) efficiency argument.

In equation (4.33d), *AS* and *ES* have opposite signs to PCM_{t-1}, implying that the relationship between *AS* and *ES* and PCM^{LR} is positive. As we discussed before, in the U.S. brewing industry, the market concentration is below the long level. An increase in *AS* and *ES* lead to an increase in λ by widening the distance between *PCM* and PCM^{LR}.

A mean value of λ is 0.096. Because λ is allowed to change over time, we plot an estimate of λ against the time in Figure 4.6. Although the path is not smooth, λ decreases over time, implying the market is in the process of convergence toward a steady state. Until around 1970, the U.S. beer market was considered regional and had a fragmented market structure. A mean value of λ during 1950-1970 is 0.129 with standard error 0.196. From 1971 through 1995, a mean value and standard error of λ decreased to 0.085 and 0.076. From 1996 on, we consider the industry concentration to be almost at the steady state level. The estimated mean and standard deviation of λ during this period are 0.042 and 0.041 respectively. The estimate of λ over time implies that the market becomes more stable as it approaches the steady state.

System Two

The second system consists of equations (4.13), (4.22) and (4.31) that we derived in section 4.2.2.

(4.13) $$PCM_t = f^2(HHI_t, AS_t, KS_t, \frac{1}{\varepsilon_{QP}}, -\varepsilon_{PA} \mid \Phi) + u_t^{PCM2}$$

(4.22) $$AS_t = g^2(PCM_t, \varepsilon_{PA}, \varepsilon_{qa}, \frac{1}{\varepsilon_{QP}}, \lambda^A \mid \Phi) + u_t^{AS2}$$

and

(4.31) $$HHI_t = \theta h^2(PCM, KS, AS, ES, \frac{1}{\varepsilon_{QP}}, \varepsilon_{PA} \mid \Phi) + (1-\theta)HHI_{t-1} + u_t^{HHI2}$$

We specify the empirical version of system two as:

(4.34a) $$PCM_t = \alpha_0 + \alpha_1 HHI_t + \alpha_2 KS_t + \alpha_3 AS_t + \alpha_4 DEM_t + D_{71-95} + D_{96-04} + e_t^{PCM2}$$

(4.34b) $$AS_t = \beta_0 + \beta_1 HHI_t + \beta_2 PCM_t + \beta_3 TV_t + \beta_4 NAS_t + D_{71-95} + D_{96-04} + e_t^{AS2}$$

and

(4.34c) $$HHI_t = \theta(\gamma_0 + \gamma_1 PCM_t + \gamma_2 AS_t + \gamma_3 KS_t + \gamma_4 ES_t + \gamma_5 DEM_t + D_{71-95} + D_{96-04}) + (1-\theta)HHI_{t-1} + e_t^{HHI2}$$

In system two, endogenous variables are HHI_t, PCM_t, and AS_t, predetermined variables are HHI_{t-1} and strict exogenous variables are KS_t, ES_t, DEM_t, TV_t, NAS_t, D_{71-95}, and D_{96-04}.

There are three features that distinguish system two from the first system. First, the concentration equation in system two is based on an "adaptive expectation model". In this model, firms form an expectation about the future profitability through a weighted average of past observations, in which the more current observation receives a greater weight and θ is the weight on the most recent information. A smaller value of θ may imply greater uncertainty due to a volatile market structure because the current market structure provides little information about the future market structure.

Second, while system one assumes that the *PCM* affects *HHI* by changing the speed of the adjustment parameter, system two assumes that the *PCM* affects *HHI* by altering expected level of *HHI*. The expectation of the *HHI* is formed according to the function that is defined in the equation (4.25), implying that the *HHI* is an increasing function of the entry cost (*ES*) and costs after the entry (*AS* and *KS*), and a decreasing function of the *PCM*.

Third, a vector of parameters, Φ, is assumed to change with the toughness of competition (e.g. a change from Cournot type to cartel behavior). In system one, a change in competition is captured by a continuous variable, such as the "war of attrition parameter" variable in (4.32 a) and the quadratic term in (4.32 b). Remember that system one synthesizes the models used in Martin (1978), Geroski et al. (1986), and Juong and Masson (2003). A continuous variable is more appropriate for their inter-industry studies where the point of regime change may be different across industries. On the other hand, system two is developed to incorporate industry specific information. Chamberline (1933), Bain (1951), and White (1976) indicate that the degree of competition may change discontinuously. In particular, there may be a critical level of concentration that supports collusion. To allow such a discrete change, we consider the use of dummy variables, each defined for a distinct competition regime.

We identify three competition regimes for the U.S. brewing industry between 1950 and 2004. The first regime appears to be 1950 through the late 1960s, in which the market was relatively regional and regional concentration may have been high.[48] The second regime runs from 1970 through 1995. This is the period where a "war of attrition game" is likely to take place. While the market was national in scope by this time, many firms remained regional and their continuous exit contributed to a rapid increase in *HHI*. In the third regime, from 1996 until present, we suspect that collusion may be an issue. In 1996, the three national brewers Anheruser-Bush, Coors, and Miller came to dominate the industry. Consequently, we define two dummy variables: $D_{71\text{-}95}$ which equals one for 1971-1995 and zero otherwise; and $D_{96\text{-}04}$ which equals one for 1996-2004 and zero otherwise.

Although Chamberline's (1933) discussion is limited in the extent to which *HHI* begin to affect the *PCM*, we consider that such changes should occur to *AS* as well because our *AS* represents the cost side of the optimization problem. That is, if the *PCM* is positively related to the critical *HHI*, *AS* should be related negatively if the advertising is combative. As a result, $D_{71\text{-}95}$ and $D_{96\text{-}04}$ are included in both equations (4.34a) and (4.35b). Also, note that these dummies are meant to capture the effect of changes in conjectural elasticity parameters α, β, η, and γ.

Finally, we include the dummies to the concentration equation (4.34c) as they might affect the expected profitability for the new entrant. For example, since 1996, the market has been

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[48] The industry is considered as concentrated since 1968 if we apply a cutoff point of 40 percent for CR4.

dominated by three leading brewers. While profit may be high for those three firms as the competition between three becomes softer, less efficient fringe firms are still under financial stress. The new entrant generally starting out with smaller scale may not be viable in this type of market. Similarly, between 1970 through 1995, competition was considered to be tough and many firms exited during this period. Therefore, we expect positive signs for D_{71-95} and D_{96-04} in equation (4.34c).

As with system one, system two may suffer from an auto-correlation bias because of the lagged dependent variable in equation (4.34c). By using the same method we applied to system one, we find no auto-correlation. As before, the Hausman test prefers the NL3SLS method over NL2SLS. Therefore, we proceed with estimating equations (4.34a) – (4.34c) by using NL3SLS. Our estimates are as follows,

$$\underset{(4.35a)}{} \quad PCM_t = \underset{(1.433)}{0.207} - \underset{(2.264)}{0.638}HHI_t + \underset{(3.363)}{0.203}KS_t + \underset{(4.572)}{3.363}AS_t + \underset{(0.497)}{0.190}DEM_t - \underset{(0.493)}{0.016}D_{71-95} + \underset{(2.609)}{0.158}D_{96-04}$$

$$\underset{(4.35b)}{} \quad AS_t = \underset{(4.448)}{-0.075} - \underset{(1.595)}{0.028}HHI_t + \underset{(2.674)}{0.070}PCM_t + \underset{(0.006)}{0.004}TV_t + \underset{(6.441)}{3.165}NAS_t + \underset{(0.501)}{0.002}D_{71-95} - \underset{(1.934)}{0.009}D_{96-04}$$

$$\underset{(4.35c)}{} \quad HHI_t = 0.145\,(\underset{(1.275)}{-0.217} - \underset{(2.151)}{0.668}PCM_t + \underset{(3.289)}{3.482}AS_t + \underset{(4.773)}{0.189}KS_t + \underset{(2.855)}{1.037}ES_t + \underset{(3.207)}{0.847}DEM_t + \underset{(0.867)}{0.018}D_{71-95} + \underset{(4.216)}{0.149}D_{96-04}) + \underset{(3.351)}{(1-0.145)}HHI_{t-1}$$

where t-statistics are in parenthesis.

In a profit equation (4.35a), the coefficients of *KS* and *AS* correspond to λ^K and λ^A, respectively. Estimated value is substantially larger for *AS* than *KS*, implying that depreciation rate of goodwill assets is higher than that of capital assets. We test an effect of competition regime changes on the market performance with dummy variables D_{71-95} and D_{96-04}. D_{71-95} also marks a transition regime from the regional market (1950 though 1970) to the national market (1971 until present), as well as the toughness of the “war of attrition game”. It has an expected sign of negative but is insignificant. Pricing seems to be less competitive from 1996-2004. D_{96-04} has a positive sign and is significant, implying the shift toward a cartel type competition increased industry profit. A coefficient estimate on *HHI* is negative, which contradicts the prediction based on equation (4.11).[49] However, in the context of (4.11), like α and β, the *HHI* can be considered as a measure of competitiveness, which is captured with $D_{71\text{-}95}$ and $D_{96\text{-}04}$ in the regression analysis.[50] What the *HHI* is capturing can be an effect of ε_{PA} as an increase in HHI is likely to increase ε_{PA} and there is no other variable controlling for ε_{PA} in (4.34a).

In the advertising equation (4.35b), *AS* increases with *PCM* which is consistent with the prediction based on the first order condition (see (4.20) and (4.21)). On the other hand, the coefficient estimate of the *HHI* is negative. As we discussed before, the first order condition cannot predict the sign on the *HHI* because it can increase *AS* by decreasing ε_{QP} or it can decrease *AS* by increasing ε_{qa}. Result of negative coefficient indicates that the *HHI* affects ε_{qa} more than ε_{QP}. As before, the effectiveness of advertising is influenced by *TV* and *NAS*. Although *TV* becomes insignificant in system two, *NAS* is still positive and significant. $D_{71\text{-}95}$ has an expected sign of positive but is insignificant. An impact of collusive behavior at a very high level of concentration is captured with dummy variable $D_{96\text{-}04}$. The estimate has a negative sign and is significant, the finding consistent with cartel behavior in an oligopoly market. Also note that, as expected, $D_{71\text{-}95}$ and $D_{96\text{-}04}$ in equation (4.35b) have opposite signs to those in (4.35a).

In concentration equation (4.35c), all variables have an expected sign and many are significant. A rate of adjustment θ is 0.145. A very low estimated value implies the current market structure provides a potential entrant with very little information about the industry's future. This makes sense as a market structure of the U.S. brewing industry has been continuously changing over the past fifty years. The coefficient estimate on the *PCM* is negative, implying that higher profits are understood by a potential entrant as a signal that more firms can operate profitably. We

[49] This result is actually consistent with past empirical studies using the U.S. data [Schmalensee (1989, p.974)]. Schmalensee (1989) notes that a profitability of industry leaders may be positively correlated with concentration ratio, but profitability of smaller firms may not be. Hence in the industry level studies a finding of weak correlation between the *PCM* and the *HHI* is possible.

[50] When we run the regression without the *HHI*, the overall results did not change except DEM whose coefficient turns to negative and insignificant.

include *AS* and *KS* to control for the rate of return. As in the profit equation, a coefficient on *AS* is substantially greater than *KS*, implying that a high *AS* signals to potential entrant that competition after entry is tough and discourages entry. This finding is consistent with Sutton's (1992) prediction where fierce advertising competition can lead to high concentration by raising endogenous sunk costs. Finally, *ES* has positive and significant impact on the entry decision. Dummies $D_{71\text{-}95}$ and $D_{96\text{-}04}$ are included because a type of competition may affect entry and/or exit decision. A positive and significant effect of $D_{71\text{-}95}$ on the *HHI* implies that a change from regional to national market promotes the exit of regional brewers. $D_{96\text{-}04}$ accounts for a cartel type competition; it has greater positive value than $D_{71\text{-}95}$. This competition may favor industry leaders and increases their power, while it puts smaller firms at a greater disadvantage.

In sum, regression results of system two are generally consistent with predictions that are derived from an oligopoly model. Especially, findings of a significant impact of *AS* and *ES* on market structure is consistent with Sutton's prediction.

4.5 Conclusion

Previous empirical SCP studies, such as Strickland and Weiss (1976), Martin (1978), Geroski et al. (1987) and Jeong and Masson (2003), estimate a system of three equations that explain concentration, profitability and advertising using inter industry data. Although successful, their approach is criticized for a lack of analytical background. In this study, we use data from a single industry where the theory can impose tighter restrictions. We develop two alternative models, one is consistent with Martin (1978) and one is consistent with Sutton (1992). In the second approach, we redefine a system of three equations as a first order condition of oligopoly profit maximizing problem. Consequently we obtain two systems. Both consist of the *PCM*, *AS*, and *HHI* equations, but the implications they generate can be very different.

Furthermore, we introduced new variables to control for industry specific details. To capture the effect of price elasticity of demand, we use *DEM*. As for the advertising elasticity of demand, we use *TV* and *NAS*. In order to capture the effect of toughness of competition, we introduced three new variables. One is a "war-of-attrition parameter" variable (N/N^*). Because this variable is continuous, we include it in system one. The other two are dummy variables $D_{71\text{-}95}$ and $D_{96\text{-}04}$, each is defined for a distinct competition regime observed in the U.S. brewing industry. Because they are discrete variables, which are likely to capture the effect of regime switching, we include them in system two.

The main contribution of this paper is the development of system two. Redefining a system of three equations as the first order conditions of a game theoretic model is new. It has a theoretical framework that has been left out of the previous studies. In both system one and system two, regression results are generally consistent with the corresponding theoretical predictions. Nevertheless, interpreting the results of system one is cumbersome as many variable estimates can be explained by alternative theoretical models. On the other hand, interpreting system two is more straightforward. At the same time, tight restrictions such as pre-specified regime dummies $D_{71\text{-}95}$ and $D_{96\text{-}04}$ are a problem if they are misspecified. The industry study within a game theoretic framework requires careful prior investigation of the industry and a unique data set. Even so, the exact timing of regime switching is still unobservable. In this sense, although analytically weak, the system one is more general. We consider that the next step is to develop a model that synthesizes system one and system two.

There are two results on which both specifications are in agreement. First, *AS* and *ES* are playing a dominant role in determining the market structure of the U.S. brewing industry. Second, whether it happens gradually or discontinuously, both regression results indicate an existence of potential collusive behavior at a very high level of concentration.

Figure 4.1 HHI of the Largest 100 Brewers,1950-2004

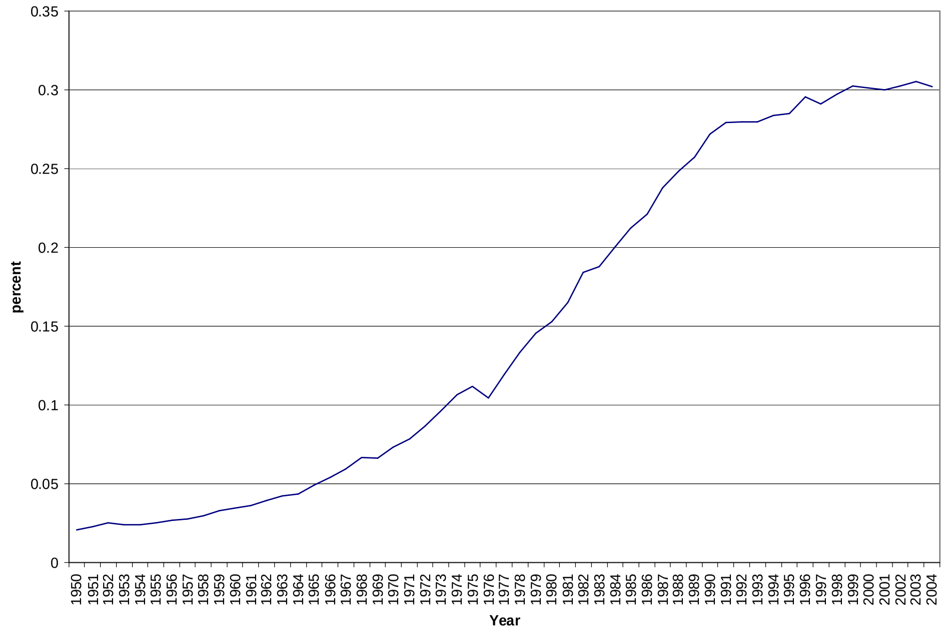


Figure 4.2 Efficient Market Share (ES),1950-2004

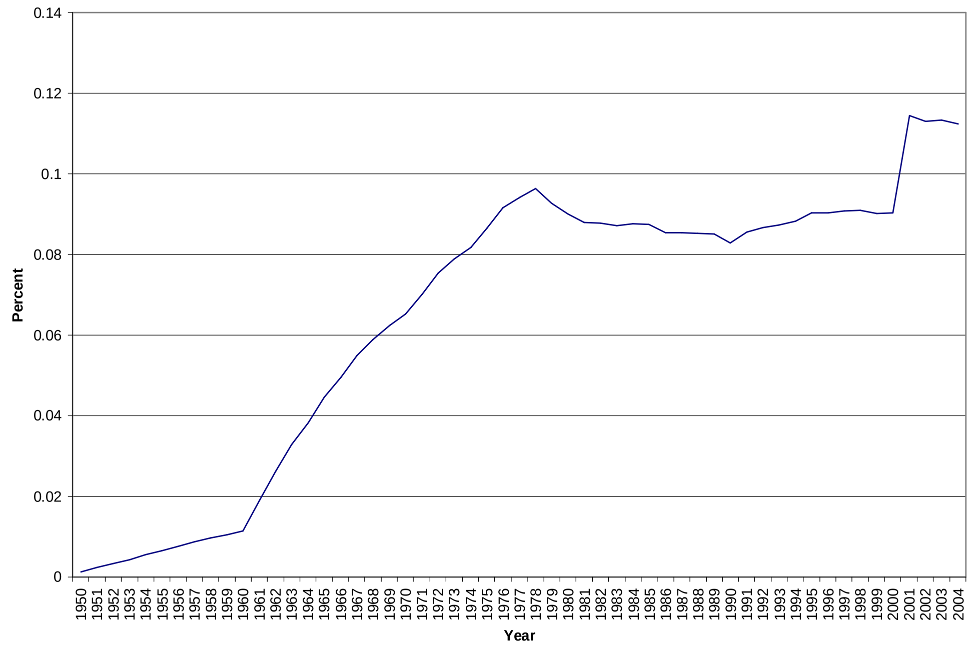


Figure 4.3 Advertising-to-Sales Ratio (AS), 1950-2004

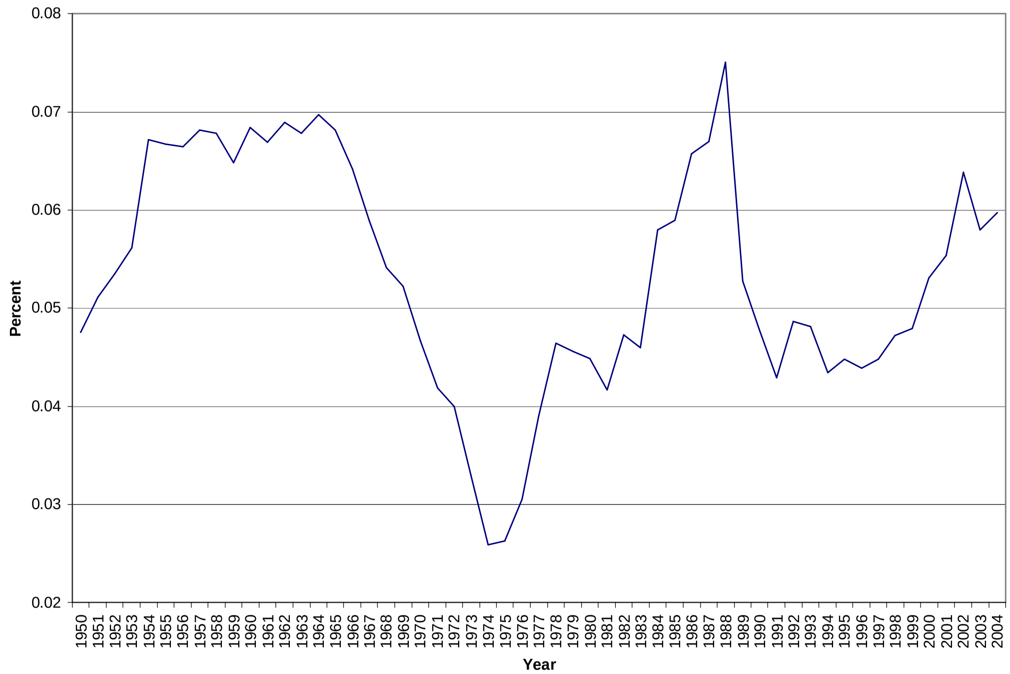


Figure 4.4 Price-Cost Margin (PCM),1950-2003

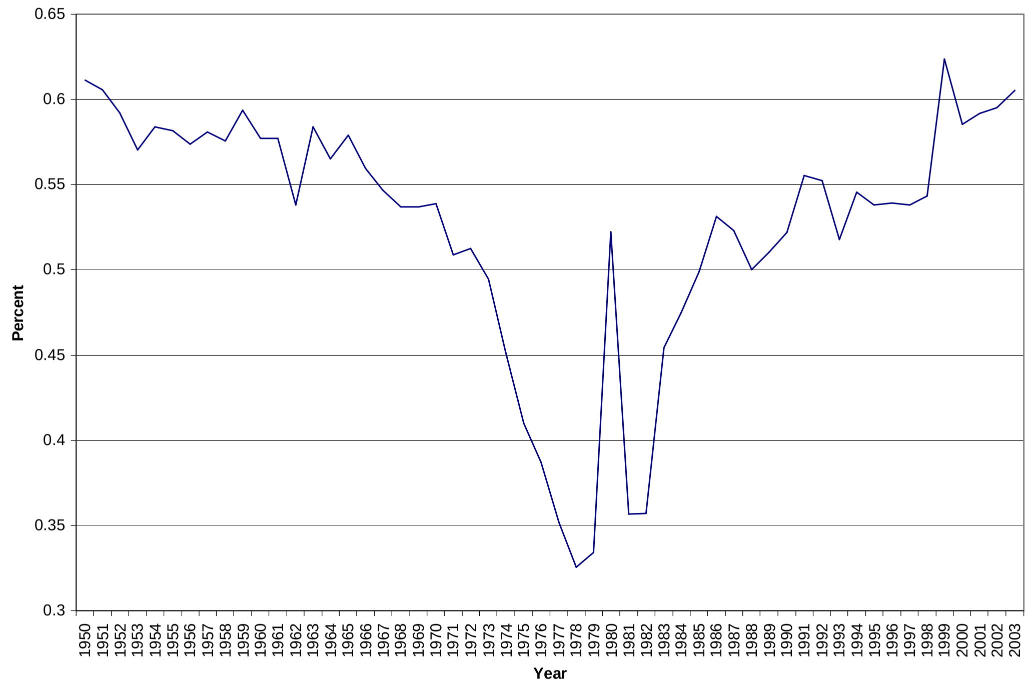


Figure 4.5: Market Share of Each of Three Largest Firms

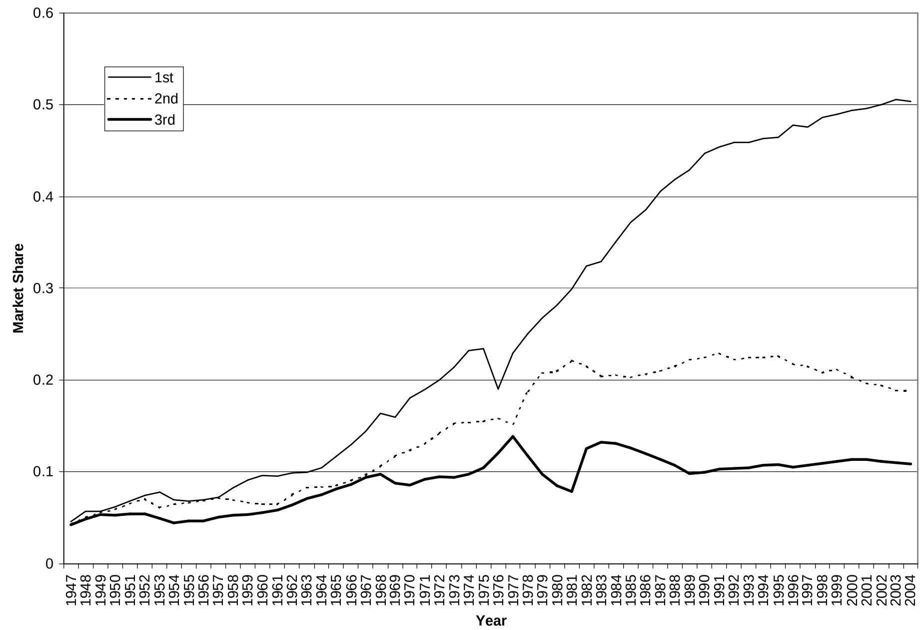
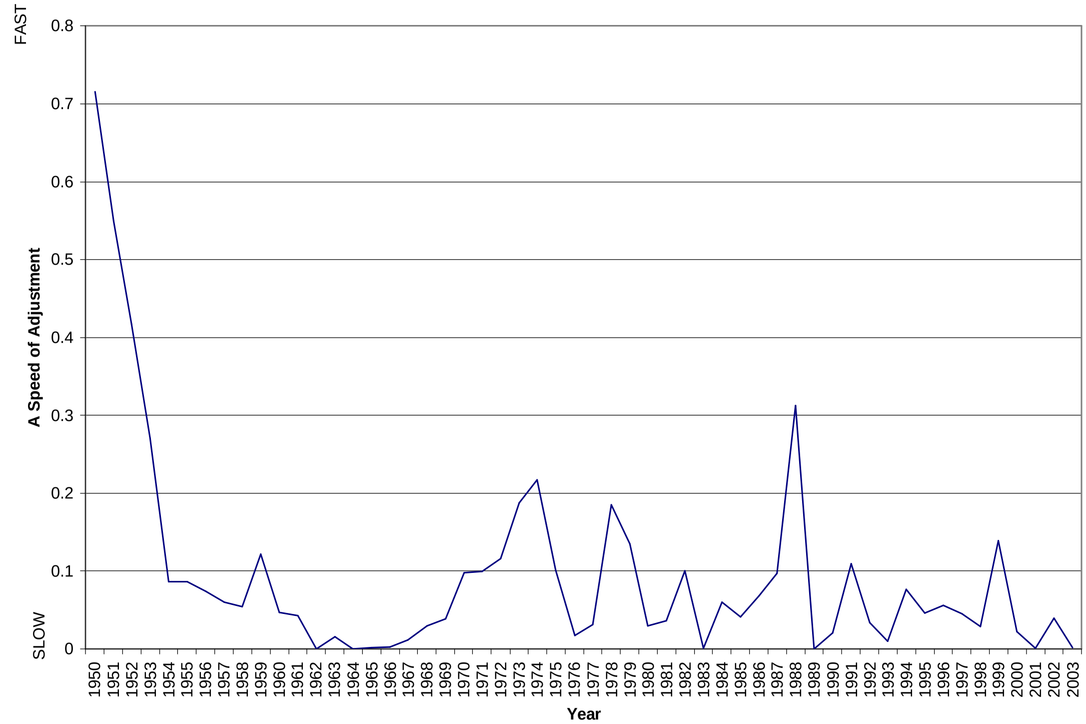


Figure 4.6 An Estimate of Speed of Adjustment Parameter (λ)



Chapter 5

General Conclusion

This dissertation addresses a dynamic effect of advertising on consumer behavior, firm behavior, and market structure and performance. Chapter 2 investigates empirically the effect of advertising regulations on the demand for an addictive commodity using the data from the U.S. cigarette industry. By using the same data set, Chapter 3 looks at the effect of advertising regulations on the industry's cost efficiency. Chapter 4 studies the effect of advertising competition on market structure and performance when advertising intensity, concentration and profitability are simultaneously determined and evolved dynamically.

The results of Chapter 2 show that the advertising regulations reduced cigarette consumption by increasing the industry's market power. In addition, a representative smoker is relatively impatient, an expected outcome for commodity like cigarette, where physical dependence, procrastination, and cognitive dissonance would lead to a high rate of time preference.

In Chapter 3, we argued that there are two potential outcomes of advertising regulations. According to the LeChatelier principle, regulations that limit substitution possibilities among inputs will reduce firm and industry cost efficiency. On the other hand, in imperfectly competitive markets, government regulation on a strategic variable such as advertising can facilitate coordination. The results show that the Broadcast advertising ban in 1971 improves the industry's cost efficiency, implying that the coordination effect dominates the LeChatelier effect.

The results of Chapter 4 indicates that an increase in minimum efficient scale and a high advertising intensity are the primarily causes of rising concentration in the U.S. brewing industry, the finding consistent with Sutton's (1992) prediction. Also we found the evidence of cartel behavior at very high level of concentration.

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APPENDICES

Appendix A

The U.S. Cigarette Industry and theU.S. Brewing Industry Data

In Chapter two, annual U.S. cigarette industry data from 1955 through 2002 are used to estimate the reduced form cigarette consumption model. Data sources, variable descriptions, means, and standard deviations for the primary data are listed in Table A.1. Price and income data are deflated by the Consumer Price Index, advertising expenditures are deflated by media price index and marginal cost is deflated by the Producer Price Index. Advertising is segmented into different regimes by interacting advertising expenditures (A_t) with appropriate dummy variables for the four different periods of advertising regulations:$A_tD_{55\text{-}67}$, $A_tD_{68\text{-}70}$, $A_tD_{71\text{-}97}$, and $A_tD_{98\text{-}02}$. The dummy variable $D_{55\text{-}67}$, (representing the period with no advertising restrictions) equals 1 from 1955 through 1967 and 0 otherwise. $D_{68\text{-}70}$, (Fairness Doctrine Act) equals 1 for 1968 through 1970 and 0 otherwise. $D_{71\text{-}97}$, (Broadcast Advertising Ban) equals 1 from 1971 through 1997 and 0 otherwise. $D_{98\text{-}02}$, (National Tobacco Settlement and the Broadcast Advertising Ban) equals 1 from 1998 through 2002 and 0 otherwise. In addition, effective marginal cost is measured as unit cost plus federal and average state taxes per cigarette.

We also construct the variable LAW_t to control for the influence of clean indoor air laws and the influence of health information on cigarette demand. LAW_t is defined as the sum of each state's share of the U.S. population times a measure of restrictiveness of each states clean indoor air laws. We use the U.S. Department of Health and Human Services (1989) definition of overall anti-smoking restrictiveness, which equals: 0 if there are no statewide anti-smoking restrictions, 1 if the state regulates smoking in 1-3 public places (excluding restaurant and private work sites), 2 if the state regulates smoking in 4 or more public places (excluding restaurant and private work sites), 3 if the state regulates smoking in restaurants (but not private work sites), and 4 if the state regulates smoking in private work sites. States with restaurant and private work site restrictions typically have several other anti-smoking restrictions. Historical facts regarding these restrictions are obtained from the U.S. Department of Health and Human Services (1989 and 1993), Chaloupka and Saffer (1992), Shelton et al. (1995), Kluger (1996), and the National Cancer Institute (2002, 2005).

The data used in Chapter 3 includes 40 annual observations from 1963 through 2002. Table A.2 lists variable definitions, measurement issues, and data sources. For each year, data are available for broadcast advertising, print advertising, and advertising in all other media. Broadcast includes the advertising expenditures on television and radio. Print includes the advertising expenditures on newspapers and magazines. The all other includes expenditures on outdoor advertising, transit advertising, direct mail advertising, commercial endorsements, testimonials by celebrities, advertisements posted at the retail location, and advertising on any medium of electronic communication. It also includes promotional expenses such as promotional allowance, public entertainment, coupons and retail values added, free samples, specialty items, and price promotions. The quantity of an advertising message by media is obtained by dividing advertising expenditures by the price of advertising for the appropriate medium. That is, the quantity of print advertising is defined as the expenditures on print advertising divided by the price of print advertising. The price is defined as the average cost of reaching an audience of one thousand, the Cost-Per-Thousand (*CPM*) for each medium. These data are obtained from Robert J. Coen, a marketing executive at Universal McCann, New York Office.

Data are collected on the quantity and price of three important classes of production inputs: labor, materials, and capital. Data on the number of all employees, payroll of all employees, the cost of materials, and the value of depreciable assets are obtained from the Census of Manufacturers [U.S. Department of Commerce (1977, 1994, 1996, 2000, and 2002)]. The price of labor is defined as employee payroll divided by the number of employees. Since stemmed tobacco leaf is the major material expense, we approximate the price of materials by the producer price index of leaf tobacco. Because this index is only available from 1985-2002, in earlier years we use the producer price index of farm products, which accounts for overall farmer costs. The price of capital is approximated by the producer price index of capital equipment. The price of cigarettes is the producer price (i.e., the market price minus state and federal taxes per unit). Following Spence (1980), we define the quality adjusted quantity of cigarettes as the dollar value of total sales, as quality improvements increase cigarette prices. To avoid biasing our inefficiency estimates, total cost includes all production and marketing expenses but does not include National Tobacco Settlement expenses.

Chapter 4 uses the U.S. brewing industry data that includes 54 observations from 1950 through 2004. *HHI*, *PCM*, *AS*, *KS*, *GR*, *IMSP*, *ES*, N/N^* and *DEM* are computed using the data provided in Tremblay and Tremblay (2005). *TV* and *NAS* are computed by using the data obtained from various issues of the Statistical Abstract of the United States. The definition, mean and standard deviation of each variable are listed in Table A.3.

Table A.1
U.S. Cigarette Industry Data: Definitions, Means and Standard Deviations of Demand & Supply Variables

Variable Name	Definition	Mean (Std. Dev.)
Q	Quantity of cigarettes domestically consumed (in millions) [8]	523762.5 (71797.8)
pcq	Per-capita quantity (in thousands) =q/(population 18 years and older) [2, 8]	3.46134 (.7725)
p	Retail price per cigarette including taxes (in cents per cigarette; 1982 $) [1, 6]	5.1294 (1.4174)
pcy	Per-capita disposable income [3, 6]	10281 (2545.91)
mc	Marginal cost proxy (in cents per cigarette) = (total cost of cigarette materials + payroll for cigarette employees + (gross value of fixed assets in cigarette industry × Moody's AAA corporate bond rate) + federal and weighted average state taxes) / q [1, 3, 5, 6, 8]	3.0103 (.6307)
D_{64}	Dummy variable for the Surgeon General's 1964 Report = 1 for 1964-2002; = 0 otherwise	.8125 (.3944)
LAW	Control for clean indoor air laws [2, 7]	33.98 (29.02)
A	Advertising expenditures (millions of 1982 $) [4, 9]	1264.22 (705.27)
$D_{55\text{-}67}$	Pre-Fairness Doctrine Act Dummy Variable =1 for 1955-67; =0 otherwise	.2708 (.4491)
$D_{68\text{-}70}$	Fairness Doctrine Act Dummy Variable =1 for 1968-70; =0 otherwise	.0625 (.2446)
$D_{71\text{-}97}$	Broadcast Advertising Ban Dummy Variable =1 for 1971-1997; =0 otherwise	.5625 (.5013)
$D_{98\text{-}02}$	National Tobacco Settlement Dummy Variable =1 for 1998-2002; =0 otherwise	.1042 (.3087)

Sources:
[1] Tobacco Institute (1985, 1992, 1995, 1997) and National Center for Tobacco-Free Kids (2002).
[2] U.S. Department of Labor (1989, 1990, 1991); U.S. Department of Commerce (1992b-2001b).
[3] Council of Economic Advisors (1980, 1991, 1995, 2002).
[4] Schmalensee (1972) and U.S. Federal Trade Commission (1992, 1996, 2002).
[5] U.S. Department of Commerce (1977, 1982, 1987, 1993a, 1994a, 1995a, 1996a, 1998, 2002).
[6] U.S. Department of Commerce (1992b-2001b).
[7] U.S. Department of Health and Human Services (1989, 1993), Chaloupka and Saffer (1992), Selton et al. (1995), Kluger (1996), and National Cancer Institute (2002, 2005).
[8] Center for Disease Control and Prevention (2002) and Federal Trade Commission (2002).
[9] Schmalensee (1972) and Universal McCann New York Office.

Table A.2
U.S. Cigarette Industry Data: Description of Cost Function Variable

Variable Name	Definition
x_{t1}	Amount of messages sent by television and radio advertising. It is obtained by dividing advertising expenditures on television and radio by Cost-per-Thousand (CPM) index of net TV and net radio [2, 8]
x_{t2}	Amount of messages sent by newspaper and magazine advertising. It is obtained by dividing advertising expenditures on newspaper and magazines by CPM index of newspaper and magazines [2, 8]
x_{t3}	Amount of messages sent by all marketing media except broadcast and print media. It is obtained by dividing the advertising expenditures by CPM index of composite and national budget. It includes the following media (available years in parentheses): Outdoor (1975-2002), Transit (1975-2002), Point-of-Sale (1963-2002), Endorsement & Testimonial (1963-2002), Direct Mail (1963-2002), Audio-visual (1963-2002), Promotional Allowances (1975-2002), (Retail, Wholesale, Other), Public Entertainment (1975-2002), Coupons & Retail value added (1985-2002), Sampling (1975-2002), Specialty item (1975-2002), Price discount (2002). Missing observations are estimated using ordinary least squares [2, 8]
x_{t4}	Amount of labor input, defined by a number of all employees (includes both production and non-production workers) [4]
x_{t5}	Amount of material input, defined by Total Cost of Materials divided by PPI of farm product/tobacco leaf. Total cost is as defined in U.S. Economic Census. In 1997, 40 % of the total cost of material is used for purchasing stemmed leaf tobacco, 8% manmade fibers, staple and tow, and the rest is divided into all other materials, containers, ingredients and supplies [4, 7]
x_{t6}	Amount of capital input, defined by depreciable assets divided by PPI of capital equipment. The depreciable assets are as defined in U.S. Economic Census. Total value of depreciable assets excludes inventories and intangible assets [4, 7]
w_{t1}	Price of broadcast advertising message, defined by CPM of Net TV and Net Radio and deflated with PPI of all commodities [7, 8]
w_{t2}	Price of print advertising message, defined by CPM of Newspapers and Magazines and deflated with PPI of all commodities [7, 8]
w_{t3}	Price of other advertising message, defined by CPM of Composite of National and Local Budget deflated with PPI of all commodities [7, 8]
w_{t4}	Price of labor input, defined by payroll of all employees divided by number of all employees and deflated with PPI of all commodities [4]
w_{t5}	Price of material input, defined by PPI of farm products for 1963-1984 and PPI of tobacco (stemmed) leaf for 1985-2002 and deflated with PPI of all commodities [7]

Table A.2 (Continued)
U.S. Cigarette Industry Data: Description of Cost Function Variable

Variable Name	**Definition**
w_{t6}	Price of capital input, defined by PPI of capital equipment and deflated with PPI of all commodities [7]
y_t	Quality adjusted output, defined as a total production multiplied by output price (before tax). It is deflated with CPI of all items [2, 3]
pcq_t	Per-capita consumption of cigarettes, defined as total consumption divided by the U.S. population over 17 years of age [2, 6]
$Cost_t$	Total cost for cigarette manufacturers. It includes costs of material, labor, capital and advertising and deflated with PPI of all commodities [4, 7]
PCM_t	Price-Cost Margin defined as the ratio of the profit to total revenue. Profit is calculated as y_t-$Cost_t$ [2, 3, 4, 6, 7]
D_{71}	Broadcast Advertising Ban Dummy =1 for 1971-2002; =0 otherwise.
D_{98}	National Tobacco Settlement Dummy =1 for 1998-2002; =0 otherwise.

Sources:
[1] Council of Economic Advisors (1980, 1991, 1995, 2002)
[2] Federal Trade Commission (2002).
[3] Tobacco Institute (1985, 1992, 1995, 1997) and National Center for Tobacco-Free Kids (2002).
[4] U.S. Department of Commerce (1972, 1977, 1982, 1995a, 1996, 1998, 2004).
[5] U.S. Department of Commerce (1995a, 2000a, 2004a)
[6] U.S. Department of Labor (1989, 1990, 1995, 1997); U.S. Department of Commerce (1992-2001) and U.S. Census Bureau (1999-2003).
[7] U.S. Department of Labor (2005).
[8] Universal McCann New York Office (2003).

Table A.3
U.S. Brewing Industry Data: Variable Definitions, Means and Standard Deviations

Variable Name	Definition	Mean (Std. Dev.)
HHI	The Hirfindahl-Hirshman Index measured with domestic consumption [1]	0.1500 (0.1079)
PCM	The Price-cost-margin measured with a ratio of the total revenue minus material cost and labor cost to the total revenue. The definition correspond to a left hand side of equation (4. 11 a) [1]	0.5253 (0.0750)
AS	Advertising-to-sales ratio measured with ratio of advertising expenditure to total revenue [1]	0.0533 (0.0119)
KS	Capital-to-sales ratio measured with ratio of values of depreciable asset (as defined in census) to total revenue [1]	0.7924 (0.2507)
GR	Annual growth rate of beer consumption [1]	0.0171 (0.0193)
DEM	Demographic measured with a ratio of population of age between 18 and 40 to a total U.S. population [1]	0.390 (0.031)
ES	Minimum efficient scale divided by total beer consumption [1]	0.0652 (0.0357)
N/N*	A ratio of the observed number to optimal number of macro brewers. An optimal number is obtained by dividing the output produced by macro brewers by the minimum efficient scale [1]	0.4159 (0.3606)
TV	A percent of households with TV sets [2]	0.8858 (0.2064)
NAS	National advertising expenditures divided by the disposable personal income [2]	0.0294 (0.0024)

[1] Tremblay and Tremblay (2005)
[2] U.S. Department of Commerce

Appendix B
Derivations of Short-run and Long-run Equilibrium Multiplier

For the rational addiction model, the short-run and long-run effects of an advertising policy change on consumption are derived from equation (2.11). The short-term effects of each policy change are:

$$\frac{\Delta q_t}{\Delta D_{68-70}} = A_t \cdot pop_t(\pi_8 - \pi_7)$$

(B1) $$\frac{\Delta q_t}{\Delta D_{71-97}} = A_t \cdot pop_t(\pi_9 - \pi_7)$$

$$\frac{\Delta q_t}{\Delta D_{98-02}} = A_t \cdot pop_t(\pi_{10} - \pi_7)$$

where pop_t is the population aged 18 and older. Each corresponds to the marginal change in consumption in year *t* when the regime changes from being unregulated (1955-1967) to each advertising regulation: the Fairness Doctrine Act (1968-1970), the Broadcast Advertising Ban (1971 on), and the National Tobacco Settlement (1998 on). Other variables are held constant at their 2002 levels, the most recent year of the data set.

Given the addictive nature of cigarette smoking, however, a change in policy today will affect future as well as current consumption. Thus, short-run and long-run effects will differ. To estimate long-run effects of a policy change, we utilize the equilibrium multipliers described in Greene (2002, 415-417). To do this, we solve equation (2.11) for pcq_{t+1} and multiply through pop_t.

(B2) $$q_{t+1} = -\frac{1}{\pi_4} pop_t\{\pi_0 + \pi_1 mc_t + \pi_2 pcy_t + \pi_3 pcq_{t-1} - pcq_t + \pi_5 D_{64} + \pi_6 LAW_t + \pi_7 AD_{55-67} + \pi_8 AD_{68-70} + \pi_9 AD_{71-97} + \pi_{10} AD_{98-02} + \varepsilon_t\}$$

Next, we reparameterize and write equation (B2) in terms of q_{t+1}, q_t, q_{t-1}, and $\underline{x}_t$.

(B3) $$q_{t+1} = \Pi_0 \underline{x}_t + \Theta_1 q_t + \Theta_2 q_{t-1} + \varepsilon_t$$

where Π_0 is a vector of parameters that corresponds to $\underline{x}_t$.

Since there are two lagged variables, we add one more equation as follows:

(B4) $$\begin{bmatrix} q_{t+1} & q_t \end{bmatrix} = \underline{x}_t' \begin{bmatrix} \Pi \\ 0 \end{bmatrix} + \begin{bmatrix} q_t & q_{t-1} \end{bmatrix} \begin{bmatrix} \Theta_1 & \Theta_2 \\ 1 & 0 \end{bmatrix} + \begin{bmatrix} \varepsilon_t' & 0 \end{bmatrix}$$

or

$$\hat{q}_{t+1}' = \underline{x}_t' A_{2\times1} + \hat{q}_t' B_{2\times2} + v_t'$$

where,

$$\hat{q}_t = \begin{bmatrix} q_{t+1} \\ q_t \end{bmatrix},\ \hat{q}_{t-1} = \begin{bmatrix} q_t \\ q_{t-1} \end{bmatrix},\ A = \begin{bmatrix} \Pi \\ 0 \end{bmatrix},\ B = \begin{bmatrix} \Theta_1 & \Theta_2 \\ 1 & 0 \end{bmatrix},\ \text{and}\ v_t = \begin{bmatrix} \varepsilon_t \\ 0 \end{bmatrix}.$$

Taking a lag of equation (B3), $\hat{q}_t' = \underline{x}_{t-1}' A_{2\times1} + \hat{q}_{t-1}' B_{2\times2} + v_t'$, and substituting for $\hat{q}_t$ in (B3) yields

(B5) $$\hat{q}_{t+1}' = \underline{x}_t' A_{2\times1} + (\underline{x}_{t-1}' A + \hat{q}_{t-1}' B + v_{t-1}') B_{2\times2} + v_t'.$$

Subsequent substitution yields

(B6) $$\hat{q}_{t+1}^{LR\prime} = \sum_{s=0}^{\infty} [x_{t-s}' A B^s] + \sum_{s=0}^{\infty} [v_{t-s}' B^s].$$

Assume that $\lim_{t\to\infty} B^t = 0$. Then

(B7) $$\hat{q}_{t+1}^{LR\prime} = x_t' A[1 + B + B^2 + B^3 + \ldots].$$

Summing the geometric series in equation (B7) to infinity reveals a simpler formula for long-run consumption of cigarettes:

(B8) $$\hat{q}_{t+1}^{LR\prime} = x_t' A[1 - B]^{-1}$$

or

(B9) $$\hat{q}_{t+1}^{LR\prime} = x_t' \begin{bmatrix} \Pi & 0 \end{bmatrix} \begin{bmatrix} 1-\Theta_1 & -\Theta_2 \\ -1 & 1 \end{bmatrix}^{-1}$$

(B10) $$\begin{bmatrix} q_{t+1} & q_t \end{bmatrix}' = x_t' \begin{bmatrix} \dfrac{\Pi}{1-\Theta_1-\Theta_2} & \dfrac{\Pi}{1-\Theta_1-\Theta_2} \end{bmatrix}.$$

The first element of the vector on the right hand side of the equation is the long run equilibrium multiplier. Fixing $\underline{x}_t$ at previous year values (2001), the marginal effect of lifting the ban and replacing it with no advertising restrictions in the long run is therefore:

(B11) $$\frac{\Delta \hat{q}_{2002}^{LR}}{\Delta D_{68-70}} = A_{2001} \cdot pop_{2001} \left(\left(-\frac{\pi_8}{\pi_4} \right) - \left(-\frac{\pi_7}{\pi_4} \right) \right) \left(1 - \left(\frac{1}{\pi_4} \right) - \left(-\frac{\pi_3}{\pi_4} \right) \right)^{-1}$$

so,

(B12) $$\frac{\Delta \hat{q}_{2002}^{LR}}{\Delta D_{68-70}} = A_{2001} \cdot pop_{2001} \cdot \left(-\frac{\pi_8}{\pi_4} + \frac{\pi_7}{\pi_4} \right) \left(1 - \frac{1}{\pi_4} + \frac{\pi_3}{\pi_4} \right)^{-1}$$

The marginal effect of replacing the Fairness Doctrine Act and the National Tobacco Settlement with the ban are respectively.

$$\frac{\Delta \hat{q}_{2002}^{LR}}{\Delta D_{71-97}} = A_{2001} \cdot pop_{2001} \cdot \left(-\frac{\pi_9}{\pi_4} + \frac{\pi_7}{\pi_4} \right) \left(1 - \frac{1}{\pi_4} + \frac{\pi_3}{\pi_4} \right)^{-1}$$

(B13)

$$\frac{\Delta \hat{q}_{2002}^{LR}}{\Delta D_{98-02}} = A_{2001} \cdot pop_{2001} \cdot \left(-\frac{\pi_{10}}{\pi_4} + \frac{\pi_7}{\pi_4} \right) \left(1 - \frac{1}{\pi_4} + \frac{\pi_3}{\pi_4} \right)^{-1}.$$

For the myopic addiction model, we follow the specification in Farr et al. (2001). The myopic version of equation (2.11) is obtained by setting π_4 equal to 0 and reparameterizing as follows

(B14) $$\begin{aligned} pcq_t = {} & \psi_0 + \psi_1 mc_t + \psi_2 pcy_t + \psi_3 pcq_{t-1} + \psi_4 D_{64} + \psi_5 LAW_t + \psi_6 AD_{55-67} + \psi_7 AD_{68-70} \\ & + \psi_8 AD_{71-97} + \psi_9 AD_{98-} v_t . \end{aligned}$$

To derive the marginal effect of policy regimes change, rewrite and reparameterize the equation as,

(B15) $$pcq_t = X_t{}' \Psi + \lambda \, pcq_{t-1}.$$

In the myopic addiction model, the changes in short-run consumption for the different policy regimes are:

$$\frac{\Delta q_t^{SR}}{\Delta D_{68-70}} = A_t \cdot pop_t \cdot (\psi_7 - \psi_6),$$

(B16)
$$\frac{\Delta q_t^{SR}}{\Delta D_{71-97}} = A_t \cdot pop_t \cdot (\psi_8 - \psi_6),$$

$$\frac{\Delta q_t^{SR}}{\Delta D_{98-02}} = A_t \cdot pop_t \cdot (\psi_9 - \psi_6),$$

Repeating the procedure used in the rational addiction model yields the formulas for long-run consumption. Evaluating the term at 2002 values is,

(B17)
$$q_{2002}^{LR} = X_{2002}^{'} \Psi [1 - \lambda]^{-1}$$

Hence, the corresponding changes in consumption are,

$$\frac{\Delta \hat{q}_{2002}^{LR}}{\Delta D_{68-70}} = A_{2002} \cdot pop_{2002} (\psi_7 - \psi_6)[1 - \lambda]^{-1}$$

(B18)
$$\frac{\Delta \hat{q}_{2002}^{LR}}{\Delta D_{71-97}} = A_{2002} \cdot pop_{2002} \cdot (\psi_8 - \psi_6)[1 - \lambda]^{-1}$$

$$\frac{\Delta \hat{q}_{2002}^{LR}}{\Delta D_{98-02}} = A_{2002} \cdot pop_{2002} \cdot (\psi_9 - \psi_6)[1 - \lambda]^{-1}$$

In summary, the parameter estimates for the model in equation (2.11) for the rational addiction model and equation (B14) for the myopic addiction model are used to derive the short and long run effects of the advertising policy regimes. For the rational addiction model, the short and long run effects are calculated from equations (B1) and (B11-13) respectively. For the myopic addiction model, the short and long run effects are calculated from equations (B16) and (B18) respectively.