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# Habit, Information and Uncertainty: Some Evidence from Natural Experiments

Junmin Wan

December 27, 2004

# Dedication

I dedicate this dissertation to my daughter, wife and parents.

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# Abstract

Chapter 1 presents the objectives of this research. Why have I undertaken research into consumers' preferences for habit, information, uncertainty, and wealth? Because a consumer's habit (historical activities), current information, and preference for uncertainty and wealth with respect to the future will essentially influence his or her decision making and activity after making the decision. The reason for using the 'natural experiment' approach is that I wish to test economic theories, and to find the causality behind economic facts, by using historical events that do not involve high costs in terms of time and money.

In Chapter 2, the hypotheses of non-addiction, myopia and rational addiction were tested using annual, quarterly, and monthly data. Changes in the price of Japanese cigarettes can be viewed as exogenous from the point of view of consumer behavior, because the Japanese government controls cigarette prices. The empirical results of this paper support the addiction hypothesis. The short-run and long-run price elasticities range from -0.338 to -0.421, and from -0.679 to -0.686, respectively; thus, increases in tax revenues in the long-run are likely to be smaller than those in the short-term. As a result, tax increases would be an effective means of curbing smoking and reducing its social cost. Furthermore, the debt compensation programs for the Japan Railway and the National Forestry will not go according to plan, unless revenues are increased in the future.

In Chapter 3, a rational addiction model with an optimal inventory was developed; this model can be used as a new way to distinguish consumption from purchases at a time when there is perfect foresight concerning price. The theoretical framework was tested using daily and monthly cigarette purchases in Japan. The rational addiction model was not supported when inventory was not considered, as the inventory became an omitted variable and correlated with price, while it was supported if the optimal inventory

was included in the estimating equation. As the tax elasticity of hoarding exceeds 400 percent, a tax increase is considered a good tool for temporary economic stimulation.

Chapter 4 clarified the effects of health information on cigarette consumption and intake of nicotine and tar in the rational addiction (RA) framework. The consumer over-consumes cigarettes because of a shortage of health information, and reduces consumption when new health information is announced. Auld and Grootendorst (2004) have pointed out that the estimable RA model tends to yield spurious evidence when aggregate data are used; if, however, prices are exogenous, instrumental variable estimates will be consistent. The Japanese cigarette price is considered exogenous because it is determined by the government. The RA model with health information is supported by Japanese monthly data and policy events. Robust evidence has also been obtained from Japanese national surveys. The consumer responds to new information by changing cigarette type, or by reducing or quitting smoking. The total intake of nicotine and tar is significantly decreased by the release of nicotine and tar content information. Tobacco control policies, such as cigarette taxes and health information, were shown to be effective, but the effect of health information was bigger than that of a tax increase.

Chapter 5 introduced a new way to examine the effects of mandatory information disclosure on inter-brand cigarette demands, and the behavior of a monopolistic firm in Japan. We estimated inter-brand demands by including nicotine, tar content, and policy event information in the model, and by using cigarette brand sales data. We found that the mandatory disclosure of nicotine and tar content information decreased the intake of nicotine and tar per capita and per smoker; thus, mandatory disclosure is likely to increase consumers' welfare, if we suppose that they always choose their favorite cigarette. Furthermore, we found that the monopolistic firm supplied a greater number of new, and better quality products, and that it discontinued the production of poorer quality goods, and conducted more R & D, in response to disclosure mandates.

In Chapter 6, the following findings were presented. The market volume of the pachinko industry exceeds 28 trillion yen, and its added value is about 0.86 percent of GDP in 1999. According to the report 'Survey of Pachinko Addiction' and 'Survey of Pachinko and the Pachinko-slot Player', pachinko gives rise to two social problems: pachinko addiction (29.3 percent of pachinko addicts think they need medical treatment), and an increased probability of household bankruptcy. Based on the estimation results using

individual data from the “Japanese Pachinko Survey 2003,” the addiction hypothesis, based on pachinko as gambling, was strongly supported. The pachinko player’s experience involved a significant decrease in the desire to stop participation in the future, an increase in the desire to commence re-initiation after quitting, and a decrease in the duration of non-playing after quitting. Thus, regulation policies for pachinko are necessary. The evidence obtained in this study may also be very helpful in a re-consideration of the assumption of risk averse behavior, and in understanding the economic phenomenon of the bubble, etc.

In Chapter 7, I used a unique individual dataset to clarify the relation between pachinko gambling and smoking. I showed that they are positively correlated, and I also showed their causality. Pachinko gambling increases smoking; thus, smoking is complementary to gambling. On the other hand, the desire to play pachinko in premises where a smoking ban is operative decreases, owing to the status of smoking in these premises; thus, pachinko is also complementary to smoking. Because smoking is harmful to health and gambling causes household bankruptcy in Japan (strong negative externalities), some regulation policies (smoking ban, etc.) are needed. Because of their complementarity, the effect of regulation is expected to be greater than usual.

In Chapter 8, I researched a new system of taxation called lottery receipts, which has been operating in China, theoretically and empirically. The budget deficit, mitigation of inequality, etc., and income redistribution have meant that the supply of public goods by an efficient and fair tax collection system has become necessary in China. However, as it is difficult for the government to act as the monitor of actual economic dealings because of information asymmetry, tax collection is not easy. Therefore, in order to bring out private information, known only to a seller and a buyer, the Chinese government has set up a lottery receipt system; this system has been tried out in a number of areas. This study considers the validity of this system, both theoretically and empirically. When the net revenue from a lottery is invested in pure public goods, Morgan (RES, 2000) has shown that public lotteries have been purchased, even if the consumer expected utility with quasi-linear preferences. By this means, the Chinese government hopes to prevent tax evasion caused by conspiracies between firms and consumers, and to collect tax effectively, to some extent, by issuing a receipt with a fixed-prize lottery ticket. In the empirical analysis, estimation that avoided self-selection was performed based on panel data for different periods from a total of 39 districts

in Beijing and Tianjin, since 1998, when the experiment started. This study finds that the receipt with lottery system has significantly increased the real growth of operating tax.

In Chapter 9, the linkage between the traditional life cycle and Ono's model was analyzed; subsequently, they were theoretically and empirically tested using time series data and surveys on lottery buyers and prize-winners. Using GMM and Japanese annual data, evidence was obtained that supports Ono's hypothesis, which implies that the Japanese consumer is characterized by an insatiable desire for money and wealth. In addition, four surveys were used to clarify who buys lottery tickets, and why, and to determine what the winners do after obtaining their prize. The reasons why individuals buy lottery tickets have been identified as, 'I want the lottery prize', and 'I had a dream about the lottery', according to 59.3 and 50.6 percent of respondents, respectively. Those in the middle income bracket are more likely to have had experience of lottery ticket purchase. Usually, a wife or a husband will receive news of a big win, but 24.7 percent of winners tell nobody. Forty-six percent of winners do not change their lifestyle after winning the lottery. On average, 39.15 (if land and housing, work and business, and investment are considered assets, averaging 52.35) percent of respondents do not increase their consumption, even if they are awarded the 8.26 million yen prize. This kind of behavior on the part of Japanese lottery winners strongly rejects the life cycle hypothesis, but supports Ono's hypothesis, while the behaviors of 60.85 percent of Japanese support the life cycle model. Thus, the effects of an income tax cut and a wealth tax cut on economic stimulation are limited or weak; a consumption tax and fiscal expenditure are expected to be more effective. An increase in family service, filial devotion to parents, and getting married are superior goods; land and housing, education and culture, the purchase of car, beautification and health, leisure time, job change or retirement status, and donations and social contributions are also superior goods. Food, clothes, and accessory traveling are unclear categories, but seem to be inferior goods.

In Chapter 10, I present the findings, problems solved, and policy proposals of this thesis, and present the issues remaining for future research.

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# Chapter 1

## Introduction

### 1.1 Objectives of this Research

There were two objectives in pursuing this study. One was to clarify the consumer preference for habit, information, and uncertainty (and wealth) in order to identify useful approaches for solving a number of economic issues (such as gambling, spurious bubble, bubble, etc.). The other was to test a number of theories in the field of economics in order to determine their causalities and validities by ‘natural experiment’, and to make a number of proposals for policy making. These two points will be elaborated more explicitly in the following section.

First, I maintain, like most economists, that a market-oriented economy is better than a centrally planned economy, as an economic system. In a market economy, however, there are series problems, such as negative externality, bubble crash, etc. For example, there have been serious consequences in the Japanese economy since the bubble crash at the end of the 1980s. Important questions in this respect are, what should be done after a bubble crash, and why did the bubble occur in the 1980s? Ogawa (2003) has pointed out that the bubble crash caused a decrease in firm investment, and an increase in bad debts, in banks. He also proposed that the bad debts of firms and banks should be resolved in order for the economy to recover. Ogawa and Wan (2004) pointed out that the bubble crash also caused bad debt within Japanese households and a decrease in consumption; they proposed that the bad debts of households should also be resolved in the current recession. These studies are ex-post and are useful for the current recession.

However, the best solution is the prevention of bubbles arising in the first place. We still do not understand clearly why this phenomenon arises. There may be many factors involved, including the behavior of consumers, firms, the government, as well as social norms, etc. I focus here on consumers' preference with respect to habit, information, uncertainty and wealth. This is because, when consumers make decisions, their habits (historical activities), current information, and preference with respect to future uncertainty and wealth will essentially influence their decisions and activity after their decisions. For example, if consumers persist in seeking money or wealth, a spurious bubble (persistent deflation) may take place<sup>1</sup>. There are also other phenomena that are analogous to an economic bubble. For example, a gambler pays for (gambling) a significantly negative expected return, and yet the purpose in gambling is to win. If the gambler is addicted to gambling, he or she may become bankrupt<sup>2</sup> (something akin to a bubble crash). If a consumer does not have sufficient information regarding goods, he or she may over- or under- consume these goods, because his or her shadow price or willingness to pay<sup>3</sup> may be mistaken, as compared to a situation in which he or she has optimal, full information.

Second, there are many theories, with supporting evidence, that offer explanations but not the causalities, or the interior mechanisms, of economic facts or issues; this is because there are too many unobservable characters with respect to economic issues. For any one economic fact, there are always many seemingly logical explanations, with the most appropriate explanation being one of many. Therefore, there could be too much theoretical "noise", which could mislead an expert or a governing body. We need to clarify which of the available explanations describes the interior mechanism of an economic phenomenon, and shows causality. This is difficult to do, because we cannot provide the solutions to social issues in the same way as conducting a natural science experiment in the laboratory. Social experiments involve huge costs and require extensive periods of time. However, if we can identify historical events that are sufficiently close to experiments, as would be performed in a laboratory, we may more easily test economic theories and identify the causality of economic phenomena. This approach has been termed that of the 'natural experiment'<sup>4</sup> in recent economic studies. I have used this approach

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<sup>1</sup>See Ono (2001) for details.

<sup>2</sup>This is described in Chapter 6.

<sup>3</sup>This point is related to chapters 4 and 5.

<sup>4</sup>There have been some interesting studies using this approach, starting from the be-

to test a number of theories (some elaborated by the author) and to make proposals for economists involved in policy making.

## 1.2 Motivation for, and Structure of, this Thesis

Why have I undertaken research into consumers' preferences for habit, information, uncertainty, and wealth? Because a consumer's habit (historical activities), current information, and preference for uncertainty and wealth with respect to the future will essentially influence his or her decision making and activity after making the decision. The reason for using the 'natural experiment' approach is that I wish to test economic theories, and to find the causality behind economic facts, by using historical events that do not involve high costs in terms of time and money.

It is very difficult to empirically test the habit, information, and uncertainty issues set out above because they are too abstract, even though these factors play invaluable roles in economics. I have found that the consumption of some unique goods and activities, such as cigarettes, pachinko gambling, and lottery gambling, can provide suitable tests for the issues of habit, information, and uncertainty. I have also found that there are many historical events that show a similarity to natural experiments in Japan, and in China. Therefore, I have analyzed these events, case by case, according to a number of standard theories in economics. In every case study or chapter, the keywords 'habit, information, uncertainty, and natural experiment' occur regularly.

Chapter 2 analyzes cigarette tax revenues versus tobacco control in Japan, within non-addiction, and myopic and rational addiction frameworks. Cigarette tax increases are always caused by a serious budget deficit in the Japanese government; thus, the tax increase with respect to cigarettes is exogenous in relation to cigarette consumers (this may be considered as a quasi-natural experiment).

Chapter 3 develops a theoretical model in which the rational addictive consumer sets out an optimal inventory for tax change, and empirically tests it. Before the tax increase, the government makes a new law implementing it, and announces it. Thus, consumers can use perfect foresight with respect

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ginning of 1990s. See Resenzweig and Wolpin (2000) for details.

to future tax and price in order to decide their own optimal consumption and inventory. There are many events of this type in Japan; these events can be considered natural experiments.

Chapter 4 develops a theoretical model in which the rational addictive consumer makes an optimal decision for consumption based on limited information about the health damage caused by consumption. This chapter also tests the model using time series data and several national surveys on smoking in Japan.

Chapter 5 introduces a new way to examine the effects of mandatory information disclosure on inter-brand cigarette demand, and the behavior of a monopolistic firm in Japan. The mandatory disclosure of nicotine and tar content can also be considered a natural experiment.

Chapter 6 analyzes the addictiveness of pachinko gambling using individual data from Japanese pachinko surveys. The gain from gambling is uncertain before the gambler participates in the activity.

Chapter 7 analyzes pachinko gambling and cigarette smoking, simultaneously, using some unique questions arising from individual data from the Japanese Pachinko Survey. The two goods are addictive, and exhibit uncertainty. Uncertainty about winning means that pachinko play constitutes gambling. Health damage occurs from smoking; thus gain from smoking is also under uncertainty.

Chapter 8 analyzes a new system of taxation implemented in China, both theoretically and empirically. A lottery receipt system has been introduced, and has been implemented as an experiment in many areas. It constitutes a real social experiment, in that it is recognized as an experiment by the present government of China. The lottery is used to avoid information asymmetry between the government and firms. The lottery buyer's gain from the lottery is uncertain.

Chapter 9 first theoretically analyzes the linkage between the Life Cycle and Ono's models, then tests them empirically using time series data and several surveys on lottery purchase and on big prize-winners in Japan. The gain from a lottery is uncertain. The prize-winners are randomly determined by the lottery numbers; this type of event also constitutes a natural experiment.

Chapter 10 concludes the study and presents some issues for future research.

### **1.3 Main Findings and Issues Left for Future Research**

The main findings and issues left for future research are summarized in Chapter 10. There have been numerous findings arising from this study, in addition to a number of proposals for economists and policy makers. See Chapter 10 for details.

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# Chapter 2

## Cigarette Tax Revenues and Tobacco Control in Japan

JEL classification: D12, E21, H29; Keywords: smoking, rational addiction, tax revenues

### 2.1 Introduction

Because smoking is harmful to human health, many countries have instituted various anti-smoking policies. For example, the 192 members of the World Health Organization (WHO) unanimously adopted the Framework Convention on Tobacco Control (FCTC), aimed at curbing tobacco-related deaths and disease, on May 21, 2003. This was the first international treaty negotiated under the auspices of the WHO. In Japan, smoking has also become a hot topic in the mass media and the Diet. The Health Enhancement Act (HEA; in Japanese, Ken Kou Zou Shin Ho) was implemented on May 1, 2003, and consisted, primarily, of anti-smoking legislation. Many policies and tools were mentioned in the FCTC and HEA, and an increase in cigarette taxes was clearly an important and common goal of the two acts. Thus, a clarification of the effect that tax increases are likely to have on cigarette consumption is important.

Cigarette consumption and the prevalence of smoking in Japan have been much higher than comparable rates in other developed countries. The WHO has pointed out that the provisions of the Japanese anti-smoking policy have been very lax, as compared to those of other developed countries. This

observation raises the question of whether Japanese anti-smoking policies, and especially tax increases, will actually reduce cigarette consumption.

In order to eliminate some of the enormous debts of the Japan Railway and the National Forestry, the Japanese Government raised the cigarette tax rate after 1998 by introducing the ‘Tobacco Special Tax’; this tax is an earmarked tax. The increase in tax revenues accruing to the Japanese government from the ‘Tobacco Special Tax’ is anticipated to be 260 to 280 trillion yen (about 2.413 to 2.598 trillion dollars in 2000 dollars) during the period 2000-2059. However, it is not clear that these revenues will be realized according to plan, or what the effects of this tax will be on overall tax revenues from cigarette taxation and on the social cost of smoking.

In addition, a new tobacco tax, called the ‘Tobacco Health Tax,’ was introduced on July 1, 2003. Based on the HEA, this tax was intended to decrease cigarette consumption and to increase tax revenue, thereby decreasing the deficit of the annual budget, a budget that had been reduced, due to gloomy economy prospects. However, the amount of revenue that the tax will actually generate, as well as the effects that the new tax will have on smoking behavior, remain unclear.

Since the social cost of smoking is very high, tobacco control is necessary; thus, an important issue in this respect is the question of which tobacco control policy will be most effective for Japan.

Chaloupka (1991), Becker, Grossman and Murphy (BGM, 1994), Bardsley and Olekalns (1999), Escario and Molina (2001), and many other authors have provided empirical results in support of the rational addiction model. The effect of anti-smoking policies, e.g., a workplace smoking ban, has been analyzed by Evans et al (1999) and by Bardsley and Olekalns (1999); their results support the view that workplace smoking bans reduce smoking. It is not yet clear, however, which hypothesis best characterizes the behavior of Japanese cigarette consumers. Specifically, is their behavior non-addictive, myopic, or rationally addictive?

This paper analyzes cigarette consumption in Japan during the period 1955-2003 from the point of view of addictive behavior<sup>1</sup>. Models of non-

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<sup>1</sup>The price elasticity of demand for Japanese cigarettes was estimated by Saito (1991). In the book, *National Accounts*, Saito estimated the price elasticity of demand for cigarettes to be  $-0.46$ , using data from the Japanese Household Consumption Expenditure survey. However, some aspects of his analysis left room for improvement, such as parts of the model and the sample, among other things. First, the analytic model used was static, because cigarettes were considered to be non-addictive goods. If smoking addiction

addiction, myopia, and rational addiction are tested respectively. The results support the rational addiction model, but reject the non-addiction and myopic addiction model. The long-run price elasticity is larger than that in the short-run. Thus, increases in tax revenues in the long-run are likely to be smaller than those in the short-run.

The models employed in this paper do not address the effects of advertising, public knowledge about the health hazards of smoking, demography, and other issues, because data on these variables are not currently available.

This paper is organized as follows. Smoking in Japan is described in Section 2. Rational, myopic, and non-addiction models are outlined in Section 3. The data and estimation techniques are presented in Section 4, and the empirical results are reported in Section 5. Japanese tobacco policy is analyzed in Section 6. Section 7 concludes the study.

## 2.2 Tobacco in Japan

### 2.2.1 Aggregate and per capita consumption

We have the cigarette consumption data in Japan from 1955 to 2002. Aggregate consumption (in packs) grew continuously, with growth accelerating until 1977 and decelerating after 1978. While cigarette consumption per capita increased greatly until 1977, it was relatively static, experiencing only a slight decrease, after 1978.

### 2.2.2 Smoking prevalence

There are data on the prevalence of smoking among Japanese adults from 1958 to 2000. There was a downward trend in smoking for males, but a stable trend for females. Figure 2.1 illustrates the prevalence of smoking among Japanese adult males by generation. All generations exhibited downward trends. Figure 2.2 illustrates the smoking prevalence for all generations of Japanese adult females. The younger generations exhibited an upward trend, while the older generations exhibited downward trends.

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were to be considered, the analytic model would have to be dynamic. Second, the sample included only worker households, not all households. Furthermore, the time-series data were for the period from 1954 to 1984; thus, cigarette consumption after 1985 was not analyzed.

### **2.2.3 Cigarette industry and imports**

The Japan Tobacco and Salt Corporation was started in 1949 and run by the Japanese government. It was then reorganized into Japan Tobacco Inc. in 1985, in accordance with Japan's Tobacco Industry Law (in place from 1985). The Ministry of Finance owned all Japan Tobacco Inc. stock until 1994, at which time one-third of the stock was sold to various private companies. At present, the Ministry of Finance continues to own two-thirds of the stock. It is indicating that the Japanese government has maintained a monopoly over the Japanese cigarette industry.

The ratio of imported cigarettes to total cigarettes consumed continued to rise, and increased remarkably in 1987, due to the removal of the import tax.

### **2.2.4 Tobacco taxes and pricing**

The tobacco tax was set by the 'Tobacco Tax Law' and the 'Local Tax Law.' In May of 1999, the national tobacco tax rate was 2,716 yen per 1,000 cigarettes. In addition, the rate of the 'Tobacco Special Tax' was 820 yen per 1,000 cigarettes, and the rate of the 'District Tobacco Tax' was 3,536 yen per 1,000 cigarettes, of which 868 yen was to be distributed to prefectures, and 2,668 yen of that sum was to go to cities, towns and villages.

Nominal cigarette prices rose seven times as a consequence of successive cigarette excise tax increases during the period 1955-2003. The real price of cigarettes greatly declined during the period 1955-1974 because of an increasing consumer price index (CPI). After 1974, real prices experienced a slight increase due to a surge in nominal prices (Figure 2.3).

### **2.2.5 Tax revenues**

Each year, when the annual budget is formulated in the Diet, the Japanese government decides the target figure for tobacco tax revenues for the following year. The total revenue from tobacco taxes in the 1999 fiscal year was 2,322,100 million yen (about 21,547 million dollars in 2000 dollars), whereas revenue from the national tobacco tax was 905 billion yen (about 8.398 billion dollars in 2000 dollars). The 'Tobacco Special Tax' was 273,600 million yen (about 2,538.799 million dollars in 2000 dollars), of which the tobacco tax to prefectures was 276,400 million yen (about 2,564.781 million dollars in

2000 dollars), and the tobacco tax to cities, towns and villages was 867,100 million yen (about 8,046.026 million dollars in 2000 dollars) from that sum.

Figure 2.4 illustrates the real cigarette tax revenues collected and real cigarette prices from 1955 to 2002. Real tax revenues exhibited an upward trend from 1955 until the end of the 1970s, while they exhibited a downward trend from 1980 to 2002. Conversely, real prices of cigarettes declined from 1955 to the end of the 1970s, while they increased slightly from 1980 to 2002. Thus, real cigarette tax revenues moved in a direction opposite to that of real cigarette prices.

### **2.2.6 Social cost**

According to ‘Tobacco control measures in the 21st century,’ a report issued by the Ministry of Health and Welfare in Japan, the extra medical expenses incurred as a result of smoking were 1.2 trillion yen (about 11.13 billion dollars in 1993 dollars) in 1993, which was just equal to the national tax revenue from cigarettes.

As indicated by Goto (1996), the total social cost to the Japanese of having a cigarette industry was 5.6 trillion yen (about 39.64 billion dollars in 1993 dollars), while the total economic benefit was 2.8 trillion yen (about 19.82 billion dollars in 1990 dollars) in 1990. Thus, the total social loss due to smoking was 2.8 trillion yen (about 19.82 billion dollars in 1990 dollars).

Therefore, from the economic point of view, tobacco control is necessary.

### **2.2.7 Tobacco control**

The Statistics of Tobacco Control Country Profiles (WHO Reports 2001) reported that the national tobacco control provisions in Japan were much less restrictive than those in other industrialized countries. For example, provisions in the following four areas were voluntary and not nationally legislated or regulated:

(1) Advertising and Sponsorship: advertising bans (cinema, internet, radio and television) and sponsorship restrictions; (2) Health Promotion and Education: institution of health education curricula or programs and public information initiatives; (3) Sales and Distribution Restrictions: the prohibition of free products or samples, the restriction of tobacco sales to certain locations, and the prohibition of the sale of smokeless tobacco; (4) Smoke-Free Indoor Air Restrictions: prohibition in air crafts, educational facilities,

government worksites, health care facilities, workplaces, etc.

The prevalence of smoking among Japanese adults and youth has also been very high. Japan has been regarded as a 'smokers' heaven,' largely as a result of the lack of tobacco controls and the high prevalence of smoking.

## 2.3 Analytical Models

### 2.3.1 Rational addiction

The theoretical model employed here follows BGM (1994). Consumers are assumed to be infinitely-lived and to maximize their lifetime utility, which is discounted at the rate  $r$ . The consumer's problem can be stated as

$$\begin{aligned} \max \sum_{t=1}^{\infty} \beta^{t-1} U(C_t, C_{t-1}, Y_t, e_t). \quad (2.1) \\ \text{s.t. } \sum_{t=1}^{\infty} \beta^{t-1} (Y_t + P_t C_t) = A^0 \\ \beta = 1/(1+r) \end{aligned}$$

Here,  $C_t$ ,  $C_{t-1}$  are the quantities of cigarettes consumed in periods  $t$  and  $t-1$ , respectively.  $Y_t$  is the consumption of the composite commodity in period  $t$ , and  $e_t$  reflects the impact of unmeasured life-cycle variables on utility. The composite commodity,  $Y$ , is taken as the numeraire, so the price of cigarettes in period  $t$  is denoted by  $P_t$ . The rate of interest is assumed to equal the rate of time preference.  $\beta$  is the time discount factor.  $A^0$  is the present value of wealth.

The associated first-order conditions are

$$U_y(C_t, C_{t-1}, Y_t, e_t) = \lambda, \quad (2.2)$$

$$U_1(C_t, C_{t-1}, Y_t, e_t) + \beta U_2(C_{t+1}, C_t, Y_{t+1}, e_{t+1}) = \lambda P_t. \quad (2.3)$$

The utility function considered is quadratic in  $Y_t, C_t$ , and  $e_t$ . By solving the first-order condition for  $Y_t$  and  $C_t$ , a linear difference equation can be derived,

$$C_t = \alpha + \theta C_{t-1} + \beta \theta C_{t+1} + \theta_1 P_t + \theta_2 e_t + \theta_3 e_{t+1}, \quad (2.4)$$

where <sup>2</sup>

$$\begin{aligned}
\alpha &= -\lambda(u_{y1} + \beta u_{y2}) \\
\theta &= \frac{-(u_{12}u_{yy} - u_{1y}u_{2y})}{(u_{11}u_{yy} - u_{1y}^2) + \beta(u_{22}u_{yy} - u_{2y}^2)} \\
\theta_1 &= \frac{u_{yy}\lambda}{(u_{11}u_{yy} - u_{1y}^2) + \beta(u_{22}u_{yy} - u_{2y}^2)} \\
\theta_2 &= \frac{-(u_{yy}u_{1e} - u_{1y}u_{ey})}{(u_{11}u_{yy} - u_{1y}^2) + \beta(u_{22}u_{yy} - u_{2y}^2)} \\
\theta_3 &= \frac{-\beta(u_{yy}u_{2e} - u_{2y}u_{ey})}{(u_{11}u_{yy} - u_{1y}^2) + \beta(u_{22}u_{yy} - u_{2y}^2)}.
\end{aligned}$$

A good is addictive if  $\theta > 0$  and the degree of addiction increases with  $\theta$ . The roots of the difference equation (2.4) are

$$\phi_1 = \frac{1 - (1 - 4\theta^2\beta)^{1/2}}{2\theta}, \quad \phi_2 = \frac{1 + (1 - 4\theta^2\beta)^{1/2}}{2\theta}, \quad (2.5)$$

and the stability conditions are

$$4\theta^2\beta < 1, \quad \phi_1 < 1, \quad \phi_2 > 1. \quad (2.6)$$

Given these roots, the temporary current, past, and future price effects are

$$\frac{dC_t}{dP_t} = \frac{\theta_1}{\theta\phi_2} \quad (2.7)$$

$$\frac{dC_t}{dP_{t-1}} = \frac{\theta_1}{\theta(\phi_2)^2} \quad (2.8)$$

$$\frac{dC_t}{dP_{t+1}} = \frac{\theta_1\phi_1}{\theta\phi_2}. \quad (2.9)$$

All roots are negative, since  $\theta_1$  is negative.

The short-run price effect is

$$\frac{dC_t}{dP^*} = \frac{\theta_1}{\theta(1 - \phi_1)\phi_2} \quad (2.10)$$

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<sup>2</sup>There seems to be a misprint in BGM (1994). According to my calculations, the last multiplicative term in the numerator of the formula for  $\theta_3$  should be  $u_{2y}u_{ey}$  instead of  $u_{2y}u_{2e}$ .

and is defined as the impact of a reduction in current and all future prices on current consumption, with past consumption held constant.

The long-run price effect is

$$\frac{dC_\infty}{dP} = \frac{\theta_1}{\theta(1 - \phi_1)(\phi_2 - 1)} \quad (2.11)$$

and is defined as the effect of a permanent reduction in prices in all periods.<sup>3</sup>

### 2.3.2 Myopic addiction

Following BGM (1994), the myopic consumer is assumed to fail to consider the impact of current consumption on future utility and future consumption. Future price and consumption changes have no impact on the current consumption of a myopic addict. Under the scenario detailed in Fenn et al. (2001), the myopic consumer faces a one-period problem:

$$\begin{aligned} \max U(C_t, C_{t-1}, Y_t, e_t). \\ \text{s.t. } Y_t + P_t C_t = A_t, \end{aligned} \quad (2.12)$$

where  $A_t$  is period  $t$  income. The solution is

$$C_t = \eta + \gamma C_{t-1} + \gamma_1 P_t + \gamma_2 e_t, \quad (2.13)$$

where

$$\begin{aligned} \eta &= -\lambda u_{y1} \\ \gamma &= \frac{-(u_{12}u_{yy} - u_{1y}u_{2y})}{(u_{11}u_{yy} - u_{1y}^2)} \\ \gamma_1 &= \frac{u_{yy}\lambda}{(u_{11}u_{yy} - u_{1y}^2)} \\ \gamma_2 &= \frac{-(u_{yy}u_{1e} - u_{1y}u_{ey})}{(u_{11}u_{yy} - u_{1y}^2)}. \end{aligned}$$

The demand equation of a myopic addict is entirely backward-looking, and current consumption depends only on current price, lagged consumption, the consumer's marginal utility of wealth, and current events. Current consumption is independent of both future consumption,  $C_{t+1}$ , and future events,  $e_{t+1}$ .

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<sup>3</sup>See BGM (1994) for details.



### 2.3.3 Non-addiction model

The ‘non-addiction’ model addresses the case in which  $\gamma$  equals 0 in equation (2.13). Here, current consumption depends only on current prices. This is a very common model of consumption demand and can be found in a standard textbook.

## 2.4 Data and Estimation Techniques

### 2.4.1 Data

The data consist of yearly, quarterly and monthly time-series for the period from January 1955 to September 2003, where the yearly data are based on the Japanese fiscal year. The quarterly and monthly data are adjusted by X-12 ARIMA.

$C_t$  denotes cigarette consumption in packs per capita. These data are taken from the ‘Japan Tobacco Association’ and ‘Public Finance Statistics’; the data consist of total sales data of cigarettes, and are divided into three subsets, according to the age of smokers: the smoking population aged ten and over, the smoking population aged fifteen and over, and the total population of smokers.

$P_t$  denotes the average real retail cigarette price per pack, which is equal to the Tobacco Price Index divided by the CPI. These data come from the ‘Annual Report on the Consumer Price Index’ and the ‘Monthly Report on the Retail Price Survey.’

$Y_t$  corresponds to real household disposable income per capita and is equal to total disposable income divided by the total population and the CPI. These yearly and quarterly data come from the ‘Report on National Accounts.’ Similarly, the monthly data come from the ‘worker household disposable income’ section of the ‘Annual Report of Family Income and Expenditure’ and, likewise, represent total disposable income per family divided by the total population.  $\Delta Y_t$  is the first difference of  $Y_t$ .

$Tax_t$  denotes real cigarette tax revenue per capita in a given fiscal year, and is equal to total national tobacco tax revenue divided by the CPI and the total population. These data come from the ‘Public Finance Statistics.’

Table 2.1 presents the means, standard deviations, and other indicators for the primary variables in the data set.

## 2.4.2 Unit root tests

If any of the variables were revealed to be nonstationary, then some problems would arise in the statistical inference using Ordinary least-squares (OLS) and two-stage least-squares (2SLS). Therefore, I test whether each variable is stationary. The ADF test and Phillips-Perron test (1988) are used for this purpose, and the results are presented in Table 2.2.

The hypotheses of unit roots for  $C_t$ ,  $P_t$  and  $\Delta Y_t$  are rejected at the 10% significance level, so these variables are considered to be either stationary or time-trend stationary. Since the unit root hypotheses for the quarterly and monthly  $Y_t$  cannot be rejected at any conventional significance level, I conclude that  $Y_t$  is not stationary. If  $Y_t$  were used in OLS and 2SLS, a bias might arise; therefore, I use  $\Delta Y_t$ .

## 2.4.3 Estimation techniques

OLS and 2SLS are used to obtain parameter estimates. The OLS estimates may not be consistent because of the endogeneity of past and future consumption, and also because of the possibility of serial correlation of the residuals. Therefore, to insure that consistent estimates are obtained, I also use 2SLS methods.

The 2SLS estimates are consistent under the instrumental variables approach<sup>4</sup>. The cigarette price is totally controlled by the Japanese government. There was a special law for every increase of cigarette tax. The seven times of cigarette tax increase were done by Japanese government not because of the situation of cigarette demand but because of the heavy deficit of public finance<sup>5</sup>. Thus the tax (or changes in cigarette prices) is an exogenous variable for the cigarette consumer. Furthermore, price is strongly correlated with cigarette consumption; thus, it is thought to be a good instrument for cigarette consumption. Price lags are used as the instrumental variables for past cigarette consumption, while price leads are used as the instrumental variables for future cigarette consumption. Finally, the Wu test is used to determine whether OLS estimates are consistent.

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<sup>4</sup>Auld and Grootendorst (2004) point that aggregate data tend to yield spurious evidence in favor of the rational addiction hypothesis. But it is also pointed in the 9th page of their paper that instrumental variable estimates of the coefficients on the lag and lead of consumption are consistent if prices are exogenous.

<sup>5</sup>See ‘The History of Japanese Tobacco Monopoly’ (in Japanese, Nihon Tabako Senbaishi).

## 2.5 Empirical results

### 2.5.1 Non-addiction and myopic addiction

The estimated values for the myopic and non-addiction models are reported in Table 2.3 <sup>6</sup>( $C_t$  is divided by the population aged 15 and over). The ‘non-addiction’ column presents the parameter estimates for the non-addiction model. The ‘basic’ column presents the parameter estimates for the basic myopic addiction model. All coefficients from the OLS and 2SLS regressions are significant at the 1% level. In the Wu test, the hypothesis that the OLS estimates are consistent cannot be rejected at the 5% level; therefore, the OLS estimates can be considered efficient when compared to those from the 2SLS procedure.

The ‘non-addiction’ model corresponds to the case in which  $\gamma = 0$  in equation (2.13). The OLS coefficient of  $C_{t-1}$  in the ‘basic’ model is significant at the 1% level. Thus, the ‘non-addiction’ model is not supported.

The ‘expanded’ column presents the parameter estimates for the expanded myopic addiction model. When the one-period lead price is added to the basic myopic addiction model, its OLS coefficient is significant at the 5% level, and its 2SLS coefficient is significant at the 1% level. These results suggest that current consumption depends on future prices. Thus it rejects myopic addiction model but is consistent with a rational addiction hypothesis. In a rational addiction model, a reduction in future prices brings about higher expected future consumption, which, in turn, raises current consumption. Hence, these results challenge the validity of the myopic addiction model. The hypothesis in the Wu test, that the OLS estimates are consistent, cannot be rejected at the 5% level.

### 2.5.2 Rational addiction

#### $C_t$ divided by the smoking population aged 15 and over

The estimated parameter values for the rational addiction model are reported in Table 2.4 ( $C_t$  is divided by the smoking population aged 15 and over). The ‘yearly,’ ‘quarterly,’ and ‘monthly’ columns present the estimates for the

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<sup>6</sup>The results based on yearly data are reported here. Other results, which are based on quarterly and monthly data, are very similar to those derived from the yearly data and are thus not reported here. The omitted results are available upon request from the author.

rational addiction model using yearly data, quarterly data,<sup>7</sup> and monthly data<sup>8</sup>. The three results are very similar.

The hypothesis in the Wu test that the OLS estimates are consistent cannot be rejected at the 5% level. Thus, the OLS estimates are considered consistent and efficient. The OLS and 2SLS coefficients on  $C_{t-1}$ ,  $C_{t+1}$  and  $P_t$  are significant, and these results provide sound support for the rational addiction model.

The OLS and 2SLS coefficients on  $Y_t$  in the ‘yearly’ column are positive but are not significant at any conventional level. These results suggest that current consumption does not depend on real disposable household income. The coefficient on  $\Delta Y_t$  in the ‘quarterly’ column is also not significant. The coefficient on  $\Delta Y_t$  in the ‘monthly’ OLS column is significantly negative.

The estimated values satisfy the stability conditions given in equation (2.6). The rational addiction hypothesis is strongly supported by all three results. Using these coefficients and the sample means from Table 2.1, I estimate the short-run and long-run price elasticities, which are shown in the rows labeled ‘short-run  $\epsilon$ ’ and ‘long-run  $\epsilon$ .’ The long-run price elasticity is about two times as large as that for the short-run.

According to the results derived from the yearly data, a 10-percent permanent increase in the price of cigarettes should reduce current consumption by 3.38 percent in the short-run, and by 6.59 percent in the long-run.

### **$C_t$ divided by the total population of smokers**

In this case, the coefficient on price is not significant, and the stability condition is not satisfied. The rational addiction model is not supported, while the myopic addiction model is supported, possibly because consumers are not given the choice to quit smoking in the latter model. This result is not contradictory to the sense of the rational addiction model, because, in that model, the consumer has the option to quit.

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<sup>7</sup>Following another paper of the author’s, the rates of tax increase are used as proxies for inventory in the estimated equation. The estimates of the coefficients on the proxies are not reported here, though there is a large inventory effect. The omitted results are available upon request from the author.

<sup>8</sup>Following another paper of the author’s, dummies are used as proxies for inventory in the estimated equation. The coefficient estimates for the proxies are not reported here but are available upon request. The inventory effect is large.

## Comparison with the U.S.

According to BGM (1994), the short-run price elasticity (taken from annual U.S. data) ranged from  $-0.355$  to  $-0.407$ , and the long-run price elasticity ranged from  $-0.734$  to  $-0.788$ . The short-run and long-run price elasticities in Japan were  $-0.338$  and  $-0.659$ . Thus, the absolute values of the short-run and long-run price elasticities in Japan are near to those in the U.S.

## 2.6 Policy analysis

### 2.6.1 Debt compensation and the reduction of pure social cost

Because of the Japanese government's monopoly of the tobacco industry, cigarette prices are entirely controlled via adjustments in cigarette tax rates. High tax rates increase cigarette prices for consumers.

The cigarette tax rate was raised in 1998. According to the 'Tobacco Special Tax,' an extra tax of 820 yen per thousand cigarettes was imposed.

A new tax called the 'Tobacco Health Tax' was introduced on July 1, 2003. The total increase in tax revenues resulting from the 'Tobacco Health Tax' is anticipated to be about 240 trillion yen.

The increase in tax revenues accruing to the Japanese government as a result of the 'Tobacco Special Tax' is anticipated at 260 to 280 trillion yen. Because the long-run price elasticity is about two times as large as the short-run price elasticity, the long-run increase in tax revenues will be much smaller than that in the short-run. According to my calculations (Table 2.5), the increase in tax revenues will be less than 260 billion yen after 2003, because of the 'Tobacco Health Tax'. Therefore, the debt compensation programs will not go according to plan.

According to Goto (1996), the pure social cost of smoking was 173.913 yen per pack in 1990. The reduction of pure social cost resulting from the 'Tobacco Special Tax' and from the 'Tobacco Health Tax' is estimated in Table 2.5, in which I also assume that all other conditions are unchanged. The reduction of the pure social cost of smoking should become greater with time and should be much greater than the reduction that accrues in the increased tax revenue.

### 2.6.2 Better policy for tax revenue

The smoking rate for Japanese males has declined. One can infer from the trend of smoking rate (or the minus coefficient of time in the Table 2.4) that consumers will probably reduce cigarette consumption gradually in the future, because of a greater awareness of health hazards, among other reasons. Thus, total cigarette consumption should decrease in the long-run. Although the current policy for total tax revenue maximization in the long-run is a lower tax rate in an unchanged smoking environment, a better policy for raising tax revenue would be to increase the current tax rate, if the government expects consumers to reduce their cigarette consumption in the future. Therefore, increases in the ‘Tobacco Special Tax’ and the ‘Tobacco Health Tax’ should be considered as better policies for raising tax revenue. In addition, the absolute value of the long-run price elasticity is smaller than one, and thus tax increases should increase total tax revenues.

### 2.6.3 Tobacco control

Due to the enormous social cost of smoking, the WHO and many other groups have proposed tobacco control policies. The Japanese government has also introduced many tobacco control provisions, most of which have been voluntary. Because price increases tend to have a negative effect on consumption, an increase in the cigarette tax would be an effective means of further tobacco control. Furthermore, such increases would be most effective in the long-term, since consumers are more sensitive to events taking place in the long-run than they are to those that occur in the short-run.

## 2.7 Conclusion

Japanese cigarette consumption has been analyzed in this study using non-addiction, myopic and rational addiction models. This analysis obtains some evidences that are not consistent with the non-addiction and myopic addiction hypotheses but consistent with the rational addiction hypothesis. The real cigarette price has a negative effect on consumption, while the effect of real household disposable income on consumption is not significant. The long-run price elasticity is about two times as large as the short-run elasticity. Thus, any long-run increase in tax revenues resulting from higher tax rates is likely to be much smaller than that in the short-run. The debt compensation

programs of the Japan Railway and the National Forestry will not proceed according to plan, as the ‘Tobacco Health Tax’ was imposed on July 1, 2003. On the other hand, these price increases should reduce the total social cost resulting from smoking and should constitute a good anti-smoking policy, bearing in mind the current state of regulations that are otherwise lax in Japan.

In this paper, the models do not treat the effects of advertising, public knowledge about the health hazards of smoking, education, and demography, etc. In fact, data for these variables are not currently available. However, it is hoped that these issues will be addressed in the future.

## Appendix: Data

**Consumer Price Index**, Statistics Bureau, Ministry of Public Management, Home Affairs, Posts and Telecommunications, Japan. *Annual Report on the Consumer Price Index*, 1955-2003.

**Consumer Price Index of Cigarettes**, Statistics Bureau, Ministry of Public Management, Home Affairs, Posts and Telecommunications, Japan. ”Subgroup Index for Japan.” *Annual Report on the Consumer Price Index*, 1955-2003.

**Nominal Household Disposable Income**, Economic Planning Agency, Government of Japan. *Report on National Accounts*, 1953-2003.

**Nominal Retail Cigarette Prices**, Statistics Bureau, Ministry of Public Management, Home Affairs, Posts and Telecommunications, Japan. ”Nationwide Uniform Prices or Charges” *Monthly Report on the Retail Price Survey*, 2000.

**Nominal Tax Revenues**, Ministry of Finance, Government of Japan. *Public Finance Statistics*, 1955-2003.

**Nominal Cigarette Prices**, Nominal Retail Cigarette Prices (2000) times the consumer price index of cigarettes divided by the index (2000).

**Per Capita Cigarette Consumption**, Total cigarette consumption divided by the Japanese population.

**Population**, Statistics Bureau and Statistics Center, Government of Japan. *Population estimates series*, 1955-2003.

**Real Household Disposable Income**, Nominal Household Disposable Income divided by the consumer price index.

**Smoking Prevalence**, Report on Smoking and Health, Ministry of Health and Welfare, Japan, 1958-2000.

**Total Cigarette Consumption**, Japan Tobacco Association, 1955-2003.



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## 2.10 Figures

## 2.11 Tables

# Chapter 3

## Rational Addiction with an Optimal Inventory: Theory and Evidence from Japanese Daily and Monthly Purchases

JEL classification: C12; D11; D12; H31; Keywords: addiction, hoarding, tax increase, omitted variable

### 3.1 Introduction

There are two main issues when estimating demand or supply equations. One is that the price becomes endogenous because demand and supply are determined simultaneously. Therefore, it is very difficult to estimate the demand or supply equation using aggregate data. A natural experiment constitutes a good approach for solving this problem. For example, Angrist et al. (2000) use typhoons as an instrument for price in estimating fish demand. The second issue is that the price becomes endogenous because some unobserved factors become omitted variables in the error term and correlate with the price. For example, rational consumer behavior, like hoarding when faced with a price increase, is correlated with price.

These two issues have not been resolved well in previous research. For example, in Becker et al. (1994), it is difficult to consider the price of cigarettes as exogenous to the consumer for two reasons. First, the price is deter-

mined by several oligopoly companies. Second, sales are considered to equal consumption, as it is very difficult to observe actual use. Thus, consumer hoarding behavior is not considered.

Recently, several papers have analyzed the consumer's inventory. Feenstra and Shapiro (2001) have pointed out that the Consumer Price Index cannot be calculated exactly if the inventory is not considered, and they have tested this using data for canned tuna. Hendel and Nevo (2001) analyzed supermarket sales and the consumer inventory and tested their model using data on soft drinks. Nevertheless, some important points have not been analyzed in detail: 1) perishable goods, 2) the correlation between inventory and the price included in the error term, 3) a suitable proxy for inventory, 4) addictive goods, and 5) the timing of hoarding.

This paper resolves these points. I develop a rational addiction model with an optimal inventory to distinguish between purchase and consumption, and I test the model using daily and monthly cigarette purchases in Japan, where the central government controls the price of cigarettes. Consequently, the price is exogenous to consumers and thus can be considered a natural experiment. Moreover, because a new law must be passed before changing cigarette taxes in Japan, the cigarette consumer has perfect foresight concerning price. Consumers are thought to hoard just before a tax increase. Therefore, purchases do not always equal consumption, especially in the short run. If the hoarding correlated with a price or tax change is not included in the estimation equation, while it is included in the error term, no consistent estimator will be obtained. In many cases consumers hoard large amounts just before a tax increase. The rational addiction model is not supported when the inventory is not considered, while it is supported when it is considered.

This paper is organized as follows: The theoretical framework is presented in Section 2. Empirical tests and results are presented in Section 3. My conclusions are presented in Section 4.

## **3.2 Theoretical framework**

### **3.2.1 Model setting**

A representative consumer is assumed to consume two types of goods: services, which cannot be stored, and addictive goods, such as cigarettes, which

can be stored for a limited time. The consumer has to choose her optimal consumption, purchase, and inventory at every period to maximize her utility and income. There are so many choices that the consumer's problem becomes very complicated. To simplify the problem, we transform it into a two-stage decision problem, without losing generality. In the first stage, the consumer is assumed to choose her optimal consumption, based on her income. In the second stage, the consumer is assumed to choose her optimal purchases and inventory, when her optimal consumption is given.

### 3.2.2 First-stage decision: optimal consumption

#### Rational addiction model

According to Becker et al. (1994), a consumer is assumed to be infinitely lived and to maximize her lifetime utility, discounted at the rate  $r$ . This utility has two components: the euphoria from addictive goods, such as cigarettes, and service. The consumer's problem can be expressed as

$$\begin{aligned} \max \sum_{t=1}^{\infty} \beta^{t-1} U(C_t, C_{t-1}, Y_t, e_t). \quad (3.1) \\ \text{s.t. } \sum_{t=1}^{\infty} \beta^{t-1} (Y_t + P_t C_t) = A^0 \\ \beta = 1/(1+r) \end{aligned}$$

Here,  $C_t$ ,  $C_{t-1}$  are the quantities of cigarettes consumed in periods  $t$  and  $t-1$ , respectively.  $Y_t$  is the consumption of the composite commodity in period  $t$ , and  $e_t$  reflects the impact of unmeasured life-cycle variables on utility. The composite commodity,  $Y$ , is taken as the numeraire, so that the price of cigarettes in period  $t$  is denoted by  $P_t$ . The rate of interest is assumed to equal the rate of time preference.  $\beta$  is the time discount factor. Any effect of  $C$  on earnings and on the present value of wealth ( $A^0$ ) is ignored. The same applies to the effect of  $C$  on other types of uncertainty. The initial condition for the consumer in period 1,  $C^0$ , measures the level of cigarette consumption in the period before the one under consideration.

The associated first-order conditions are

$$U_y(C_t, C_{t-1}, Y_t, e_t) = \lambda, \quad (3.2)$$

$$U_1(C_t, C_{t-1}, Y_t, e_t) + \beta U_2(C_{t+1}, C_t, Y_{t+1}, e_{t+1}) = \lambda P_t. \quad (3.3)$$

A consumption euphoria function that is quadratic in  $Y_t, C_t$ , and  $e_t$  is considered. By solving the first-order condition for  $Y_t$  and substituting it into the first-order condition for  $C_t$ , a linear difference equation can be derived,

$$C_t = \theta_0 + \theta C_{t-1} + \beta\theta C_{t+1} + \theta_1 P_t + \theta_2 e_t + \theta_3 e_{t+1} \quad (3.4)$$

where <sup>1</sup>

$$\begin{aligned} \theta_0 &= -\lambda(u_{y1} + \beta u_{y2}) \\ \theta &= \frac{-(u_{12}u_{yy} - u_{1y}u_{2y})}{(u_{11}u_{yy} - u_{1y}^2) + \beta(u_{22}u_{yy} - u_{2y}^2)} \\ \theta_1 &= \frac{u_{yy}\lambda}{(u_{11}u_{yy} - u_{1y}^2) + \beta(u_{22}u_{yy} - u_{2y}^2)} \\ \theta_2 &= \frac{-(u_{yy}u_{1e} - u_{1y}u_{ey})}{(u_{11}u_{yy} - u_{1y}^2) + \beta(u_{22}u_{yy} - u_{2y}^2)} \\ \theta_3 &= \frac{-\beta(u_{yy}u_{2e} - u_{2y}u_{ey})}{(u_{11}u_{yy} - u_{1y}^2) + \beta(u_{22}u_{yy} - u_{2y}^2)}. \end{aligned}$$

A good is addictive if  $\theta > 0$ , and the degree of addiction increases with  $\theta$ . The roots of the difference equation (3.4) are

$$\phi_1 = \frac{1 - (1 - 4\theta^2\beta)^{1/2}}{2\theta}, \quad \phi_2 = \frac{1 + (1 - 4\theta^2\beta)^{1/2}}{2\theta}, \quad (3.5)$$

and the stability conditions are

$$4\theta^2\beta < 1, \quad \phi_1 < 1, \quad \phi_2 > 1. \quad (3.6)$$

Given these roots, the temporary current, past, and future price effects are

$$\frac{dC_t}{dP_t} = \frac{\theta_1}{\theta\phi_2} \quad (3.7)$$

$$\frac{dC_t}{dP_{t-1}} = \frac{\theta_1}{\theta(\phi_2)^2} \quad (3.8)$$

$$\frac{dC_t}{dP_{t+1}} = \frac{\theta_1\phi_1}{\theta\phi_2}. \quad (3.9)$$

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<sup>1</sup>There appears to be a misprint in Becker et al. (1994). According to my calculations, the last multiplicative term in the numerator of the formula for  $\theta_3$  should be  $u_{2y}u_{ey}$  instead of  $u_{2y}u_{2e}$ .



All the roots are negative, since  $\theta_1$  is negative.

The short-run price effect is

$$\frac{dC_t}{dP^*} = \frac{\theta_1}{\theta(1 - \phi_1)\phi_2}, \quad (3.10)$$

which is defined as the impact of a reduction in the current and all future prices on current consumption, with past consumption held constant.

The long-run price effect is

$$\frac{dC_\infty}{dP} = \frac{\theta_1}{\theta(1 - \phi_1)(\phi_2 - 1)}, \quad (3.11)$$

which is defined as the effect of a permanent reduction in prices in all periods.<sup>2</sup>

### Issues in the empirical analysis

The consumption set  $(C_1, \dots, C_T)$  is decided optimally, although in the empirical analysis  $C$  is very difficult to observe. We often lack consumption data and have aggregate data on purchases. Nevertheless, purchases do not equal consumption, especially in the short run.

### 3.2.3 Second-stage decision: optimal purchase and inventory

#### Optimal purchases and inventory when the consumption is given

The optimal consumption set in the first-stage problem is assumed to be given. In this stage, the consumer is assumed to choose her optimal purchases and inventory in every period. In this model, we make the following assumptions to simplify the analysis, without losing generality.

Cigarettes are perishable, and have a best-before date or a time limit. This period is assumed to be  $T^l$ . According to ‘The History of the Japanese Tobacco Monopoly’, this period is about 5 months. I also assume that there are no new tax increases or decreases during this period, after a tax or price change. I also assume that the price is known with perfect foresight. This is the case in Japan, because the Japanese government regulates cigarette prices. The Japanese Diet must enact a new law before any tax increase can

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<sup>2</sup>See Becker et al. (1994) for details.

be implemented. The inventory cost is assumed to be a function of inventory,  $F(I_t)$ , where  $F'(I_t) > 0, F''(I_t) > 0, F(0) = 0$ . The shopping cost is assumed to be zero; this is reasonable because cigarette vending machines are located everywhere in Japan.

Under these assumptions, the consumer's optimal strategy is when the inventory is zero and purchases equal consumption in the period after time  $T^l$ . Therefore, the consumer considers a cost minimization problem during one cycle of the cigarette storage time limit.

$$\begin{aligned} \min_{Q_t, I_t} &= \sum_{t=1}^{T^l} (1+r)^{-t} [P_t Q_t + F(I_t)]. & (3.12) \\ \text{s.t. } & -I_t \leq 0; \\ & -Q_t \leq 0; \\ & I_t = Q_t + I_{t-1} - C_t; \\ & Q_0 > 0; \quad I_0 = 0; \quad P_t > 0; \quad C_t > 0; \quad I_{T^l} = 0. \end{aligned}$$

The Lagrangean function can be written

$$\begin{aligned} L = \sum_{t=1}^{T^l} (1+r)^{-t} [P_t Q_t + F(I_t)] &+ \sum_{t=1}^{T^l} \lambda_t \cdot (-I_t) + \sum_{t=1}^{T^l} \gamma_t \cdot (-Q_t) \\ &+ \sum_{t=1}^{T^l} \mu_t \cdot [I_t - (Q_t + I_{t-1} - C_t)]. \end{aligned} \quad (3.13)$$

where,  $\lambda_t, \gamma_t, \mu_t$  are the Lagrangean multipliers. The first order conditions are

$$\frac{\partial L}{\partial Q_t} = 0, \quad \rightarrow \quad (1+r)^{-t} P_t - \gamma_t - \mu_t = 0; \quad (3.14)$$

$$\frac{\partial L}{\partial I_t} = 0, \quad \rightarrow \quad (1+r)^{-t} F'(I_t) - \lambda_t + (\mu_t - \mu_{t+1}) = 0; \quad (3.15)$$

$$\frac{\partial L}{\partial \mu_t} = 0, \quad \rightarrow \quad I_t - (Q_t + I_{t-1} - C_t) = 0. \quad (3.16)$$

**Proposition 3.1:** If a price or tax increase occurs at time 2,  $(1+r) < P_2/P_1$  and the price remains constant until time  $T^l$ , the optimal strategy

for purchases and inventory is to buy new cigarettes only if the inventory becomes zero, and the optimal inventory after time 2 decreases with time, due to consumption. The proof is in Appendix A.

**Proposition 3.2:** If the price or tax increases at time 2,  $(1+r) < P_2/P_1$  and the price remains constant until time  $T^l$ , the optimal inventory at time 1 is unique.  $0 \leq I_1^* \leq \sum_{t=2}^{T^l} C_t$  and  $I_1^*$  is a function of  $\frac{P_2}{P_1}$ , inventory cost, and the time limit. It increases with  $\frac{P_2}{P_1}$  and the time limit, but decreases with the inventory cost. The proof is in Appendix A.

Following Proposition 3.1, the consumer's purchases will be zero if the inventory exceeds the consumption during time t. Therefore, before a price or tax increase, purchases will exceed consumption, while purchases will be zero during some period after a price or tax increase. In addition,  $\Delta I_1 = I_1$  because  $I_0 = 0$ . We can test such optimal consumer behavior in an empirical analysis.

### 3.2.4 Solutions to the issues raised in the empirical model

In the first-stage problem, the consumption set is derived. However, we cannot observe the aggregate quantity of consumption. We only have purchase data. Therefore, we must use the purchase equation in the second stage and substitute purchases for consumption  $C_t$  in the first stage.

$$\begin{aligned} Q_t &= I_t - I_{t-1} + C_t = \Delta I_t + C_t \\ &= \theta_0 + \theta C_{t-1} + \beta \theta C_{t+1} + \theta P_t + \theta_2 e_t + \theta_3 e_{t+1} + \Delta I_t. \end{aligned} \quad (3.17)$$

Note here,  $C_{t-1} = Q_{t-1} - \Delta I_{t-1}$ ,  $C_{t+1} = Q_{t+1} - \Delta I_{t+1}$ . Therefore,  $Q_t$  can be represented in the following form,

$$\begin{aligned} Q_t &= \theta_0 + \theta Q_{t-1} + \beta \theta Q_{t+1} + \theta P_t + \theta_2 e_t + \theta_3 e_{t+1} \\ &\quad + (\Delta I_t - \theta \Delta I_{t-1} - \beta \theta \Delta I_{t+1}). \end{aligned} \quad (3.18)$$

$(\Delta I_t - \theta \Delta I_{t-1} - \beta \theta \Delta I_{t+1})$  is the effect of inventory, where,

$$Cov(P_t, \Delta I_t - \theta \Delta I_{t-1} - \beta \theta \Delta I_{t+1}) \neq 0.$$

Since the inventory also correlates with the tax change or the lead and lag of the price, the error term will correlate with the price (or tax rate) when  $(\Delta I_t -$

$\theta\Delta I_{t-1} - \beta\theta\Delta I_{t+1}$ ) is not included in the right hand side of the structural model. This is a typical endogenous issue caused by omitting a variable correlated with the explanatory variable.

In the second-stage decision problem, I derive the optimal inventory and know  $\Delta I_t$  in every period. Therefore, I can use  $T^l$  dummies to indicate  $\Delta I_t$ , one dummy for the hoarding effect, and  $T^l - 1$  dummies for storage effects after hoarding. Since the time limit of Japanese cigarettes is about 5 months and distribution takes about 2 months, the consumer storage period is about 3 months.

<i>Time,</i>	<i>Price<sub>t</sub>,</i>	<i>Hoarding<sub>t</sub>,</i>	<i>Store1<sub>t</sub>,</i>	<i>Store2<sub>t</sub>,</i>	<i>Store3<sub>t</sub>.....</i>	<i>StoreT<sup>l</sup><sub>t</sub></i>
t-4	P <sub>1</sub>	0	0	0	0 .....	0
t-3	P <sub>1</sub>	0	0	0	0 .....	0
t-2	P <sub>1</sub>	0	0	0	0 .....	0
t-1	P <sub>1</sub>	0	0	0	0 .....	0
t	P <sub>1</sub>	(P <sub>2</sub> / P <sub>1</sub> )	0	0	0 .....	0
t+1	P <sub>2</sub>	0	(P <sub>2</sub> / P <sub>1</sub> )	0	0 .....	0
t+2	P <sub>2</sub>	0	0	(P <sub>2</sub> / P <sub>1</sub> )	0 .....	0
t+3	P <sub>2</sub>	0	0	0	(P <sub>2</sub> / P <sub>1</sub> ) .....	0
t+4	P <sub>2</sub>	0	0	0	0 .....	0
t+T <sup>l</sup>	P <sub>2</sub>	0	0	0	0 .....	(P <sub>2</sub> / P <sub>1</sub> )
t+T <sup>l</sup> + 1	P <sub>2</sub>	0	0	0	0 .....	0

According to the second-stage problem, the extent of hoarding is a function of tax increases, and the tax increase rate is a good proxy for hoarding. Therefore, each of the seven tax increases is used to examine the effects of hoarding and storage.

$$\begin{aligned}
Q_t &= \theta_0 + \theta Q_{t-1} + \beta\theta Q_{t+1} + \theta P_t + \theta_2 e_t + \theta_3 e_{t+1} \\
&+ (\Delta Hoarding_t + \Delta Store1_t + \Delta Store2_t + \Delta Store3_t) \\
&- \theta(\Delta Hoarding_{t-1} + \Delta Store1_{t-1} + \Delta Store2_{t-1} + \Delta Store3_{t-1}) \\
&- \beta\theta(\Delta Hoarding_{t+1} + \Delta Store1_{t+1} + \Delta Store2_{t+1} + \Delta Store3_{t+1})
\end{aligned}$$

Since the inventory has the characteristics shown in Figure 3.1, it can be written as,

$$\begin{aligned}
\Delta Hoarding_t &= -a\Delta Store1_{t+1}, \\
&= -b\Delta Store2_{t+2}, \\
&= -c\Delta Store3_{t+3}, \quad for \quad 1 < a, b, c,
\end{aligned}$$

Therefore, the variables on the right hand side can be written

$$\begin{aligned}
\Delta Hoarding_{t-1} &= -a\Delta Store1_t, \\
\Delta Store1_{t-1} &= (b/a)\Delta Store2_t, \\
\Delta Store2_{t-1} &= (c/b)\Delta Store3_t, \\
\Delta Store1_{t+1} &= (-1/a)\Delta Hoarding_t, \\
\Delta Store2_{t+1} &= (a/b)\Delta Store1_t, \\
\Delta Store3_{t+1} &= (b/c)\Delta Store2_t,
\end{aligned}$$

then  $Q_t$  can be written

$$\begin{aligned}
Q_t &= \theta_0 + \theta Q_{t-1} + \beta\theta Q_{t+1} + \theta P_t + \theta_2 e_t + \theta_3 e_{t+1} \\
&+ (-\theta)Hoarding_{t+1} + (1 + \beta\theta/a)Hoarding_t + (1 + \theta a(1 - \beta/b))Store1_t \\
&+ (1 - \theta b/a - \beta\theta b/c)Store2_t + (1 - \theta c/b)Store3_t + (-\theta)Store3_{t-1} \quad (3.20)
\end{aligned}$$

Before a price increase, purchases exceed consumption and hoarding has a positive effect on purchases. Therefore,  $\Delta Hoarding_{t+1} > 0$  and  $\Delta Hoarding_t > 0$ . Moreover, because  $0 < \theta < 1$  and  $0 < \beta < 1$ ,  $(-\theta)\Delta Hoarding_{t+1} < 0$  and  $(1 + \beta\theta/a)\Delta Hoarding_t > 0$ . After the price increase, because the inventory must have a negative effect on purchases,  $\Delta Store1_t < 0$ ,  $\Delta Store2_t < 0$ ,  $\Delta Store3_t < 0$ , and  $\Delta Store3_{t-1} < 0$ . Therefore,  $(1 + \theta a(1 - \beta/b))\Delta Store1_t < 0$ ,  $(-\theta)\Delta Store3_{t-1} > 0$ , and the signs of  $(1 - \theta b/a - \beta\theta)\Delta Store2_t$  and  $(1 - \theta c/b)\Delta Store3_t$  are undetermined.

This purchase equation,  $Q_t$  is estimated in the following section. I have data on the variables and suitable proxies for the inventories.

### 3.3 Empirical test for the rational addiction model with an optimal inventory

#### 3.3.1 Daily purchases before and after a tax increase

Cigarette prices are controlled by the Japanese government. Cigarette tax increases can be considered a natural experiment for testing the consumer's response to price change. A new cigarette tax increase law was passed on March 4, and came into effect on July 1, 2003. Daily purchase data for cigarettes in Japan, from April 1 to September 30, are shown in Figure 3.2.

The horizontal axis shows the purchase date and the vertical axis shows the daily purchases. In Figure 3.2, there is a big rise in purchases, beginning on June 23, about one week before the price increase, which peaked on June 30, one day before the price increase. This is the hoarding effect that is due to the tax increase, and it is consistent with the prediction of the theoretical model in the previous section. After the price increase on July 1, purchases declined. This is the storage effect that is due to hoarding, and it is also consistent with the prediction of the theoretical model.

We can compare the purchases before and after the tax increase with the average purchases in Table 3.1. The average daily purchase per family was 37.43 yen from April 1 to September 30. The purchases on June 30 were 8.89 times the average daily purchase, and the purchases after the tax increase decreased markedly.

### **Monthly purchase frequency before and after a tax increase**

Table 3.2 shows that the frequency of purchases in June 2003, the month just before the tax increase, increased markedly, and decreased markedly in July. This is consistent with the prediction of the inventory model.

### **Monthly purchases before and after a tax increase**

From Table 3.2 and Figure 3.3, it is clear that the cigarette expenditure per family in June increased markedly, while it decreased markedly in July 2003. This is also consistent with the optimal inventory theory.

## **3.3.2 Formal test of the addiction model using monthly data**

In Japan, cigarette price or tax changes are totally exogenous to the cigarette consumer and can be considered a natural experiment. The exogenous price is suitable for estimating the cigarette purchase or demand equation.

### **Data set for an econometric model**

The following data<sup>3</sup> consist of monthly series from Jan. 1954 to Sept. 2003.

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<sup>3</sup>The details are shown in Appendix B.

**(Cigarette purchases by Japanese worker households)**  $Purchase_t$  is the monthly total of cigarette purchases, in packs, per capita. The data are taken from the ‘Annual Report of Family Income and Expenditure Survey’, and are seasonally adjusted using X-12 ARIMA.

**(Price)**  $Price_t$  is the real average retail cigarette price per pack in month  $t$ . It equals the Tobacco Price Index divided by the Consumer Price Index (CPI). These data are taken from the ‘Annual Report on the Consumer Price Index’ and the ‘Monthly Report on the Retail Price Survey’. It is seasonally adjusted using X-12 ARIMA, and the units are 100 yen, in 1995, per pack.

**(Disposable income)**  $Y_t$  is the real monthly worker household disposable income per capita. These data are taken from the ‘Annual Report of Family Income and Expenditure Survey’. It equals the total disposable income per family, divided by the total population per family and the CPI. It is seasonally adjusted using X-12 ARIMA, and the units are 1000 yen, in 1995, per capita.

**(First difference of the disposable income)**  $\Delta Y_t$  is the first difference of the monthly disposable income and the units are 1000 yen, in 1995, per capita.

The summary statistics of these variables are shown in Table 3.3.

### Unit root tests

If any of the variables are non-stationary, problems can arise from a statistical inference using the least-squares (OLS) or two-stage least-squares (2SLS) method. Therefore, we test whether each variable is stationary, using the ADF and Phillips-Perron test. The test results are reported in Table 3.4.

The unit roots of  $Purchase_t$  with time are rejected at the 1% significance level. The unit roots of  $Price_t$  are rejected at the 5% significance level. Since the unit roots of  $Y_t$  cannot be rejected at any conventional significance level,  $Y_t$  is not stationary. Since the unit roots of  $\Delta Y_t$  with time are rejected at the 1%, it is considered stationary over time.

### Estimation technique

OLS and 2SLS are used to obtain the parameter estimates. The OLS estimates may not be consistent estimates because of the endogeneity of past and future consumption (or purchases) and the serial correlation in the residuals. To obtain consistent estimates, I use 2SLS methods.

The 2SLS estimates are consistent using instrument variables. The price of cigarettes is an exogenous variable for the consumer. Furthermore, the price strongly correlates with cigarette consumption; therefore, it is a good instrument variable for cigarette consumption (or purchases). The lagged prices and taxes are used as the instrument variables for past cigarette consumption (or purchases), while the leads of price and taxes are used as the instrument variables for future cigarette consumption (or purchases).

The Wu test is used to determine whether the OLS estimates are consistent. The over-identification test (OID) is used to test the validity of the overidentifying restrictions.

### **Estimation results without distinguishing between purchases and consumption**

The estimated values are reported in Table 3.5. Since  $Purchase_t$ ,  $Price_t$ , and  $\Delta Y_t$  are stationary with time, the time trend is included in the estimation equation. In the OLS column, the results are considered inconsistent estimates because of endogenous explanatory variables. In the 2SLS column, the coefficient of  $Price_t$  is negative and significant. The coefficients of  $Purchase_{t-1}$  and  $Purchase_{t+1}$  are negative and significant. The sign of the estimated coefficients of  $Purchase_{t-1}$  and  $Purchase_{t+1}$  does not satisfy the addiction condition. These results appear to be a durability effect.

According to the OID test, the set of instruments is invalid. This means that the instruments correlate with the error term, which causes the problem of sign inversion. Therefore, the influence of the inventory is very serious. If it is ignored, consistent estimates cannot be obtained.

### **Estimation results distinguishing between purchases and consumption**

The results are reported in Table 3.6. Since  $Purchase_t$ ,  $Price_t$ , and  $\Delta Y_t$  are stationary over time, the time trend is included in the estimation equation. The set of instruments in the 2SLS is valid, according to the OID test. The hypothesis that the OLS estimates are consistent can be rejected at the 5% level using the Wu test. Therefore, the 2SLS estimates are consistent.

In the 2SLS column, the coefficient of  $Price_t$  is negative and significant. The coefficients of  $Purchase_{t-1}$  and  $Purchase_{t+1}$  are negative and significant. The sign of the estimated coefficients of  $Purchase_{t-1}$  and  $Purchase_{t+1}$



satisfies the addiction condition. The estimated values also satisfy the stability conditions.

The coefficients of  $Store2_t$ ,  $Store3_t$ , and  $Store3_{t-1}$  are not significant. The coefficients of  $Hoarding_{t+1}$ ,  $Hoarding_t$ , and  $Store1_t$  are significantly negative, positive, and negative, respectively. These results are consistent with the predictions of the rational addiction model with an optimal inventory.

Therefore, the model is strongly supported by Japanese monthly purchases.

I use the estimated coefficients and sample means in Table 3.3 to estimate the short- and long-run price elasticity shown in the rows ‘*short-run  $\epsilon$* ’ and ‘*long-run  $\epsilon$* ’, respectively. The long-run price elasticity is about 2.681 times greater than the short-run value<sup>4</sup>.

### The amount of hoarding versus the rate of tax increase

The amount of hoarding before every tax increase is calculated. According to the prediction of the theoretical model, the amount of hoarding equals the purchase difference between the two months just before the tax increase, if consumption in those two months is unchanged. The result is presented in Table 3.7. The amount of hoarding increases with the rate of the tax increase.

$$\begin{aligned} \text{tax elasticity of hoarding} &= \frac{(\text{average hoarding})/(\text{average purchase})}{\text{average rate of tax increase}} \times 100\% \\ &= \frac{1.126/1.475}{0.183} \times 100\% \\ &= 418.067\%. \end{aligned}$$

The tax elasticity of hoarding is astonishingly large. This implies that the consumer will hoard more than four times as much as the average purchase if the tax rate increases 100 percent.

## 3.4 Conclusion

This paper presents an approach that distinguishes between purchases and consumption. Future price information is used to distinguish between pur-

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<sup>4</sup>The elasticity is higher than that in Wan (September 2002) because the health information effect is not considered here.

chases and consumption. If a rational consumer has information on a future price decrease, she will not hoard cigarettes, and the purchase of cigarettes can be considered as her consumption. However, if that rational consumer has information on a future price increase, she will hoard cigarettes just before the price increase because cigarettes have a ‘pull-date’. Therefore, purchases exceed consumption. The rate of tax increase is used as a proxy variable for hoarding and stock to express the consumer response to price information.

Since the Japanese government has total control of the price of cigarettes, the price is completely exogenous to the cigarette consumer and can be considered a natural experiment. The price of cigarettes is suitable for testing the consumer’s response to a price change in terms of purchases and consumption.

The effect of hoarding and stock is astonishingly large. The tax elasticity of hoarding cigarettes exceeds 400 percent. If the hoarding and stock effects are not considered, the problem of sign inversion (the addiction effect becomes the durability effect) will arise and consistent estimators will not be obtained. This occurs because the price or tax correlates with the error term when the consumer’s optimal inventory behavior is not considered.

The rational addiction model with an optimal inventory is strongly supported by monthly household data for Japanese workers. The consumer responds to information about a price increase by hoarding cigarettes and reducing consumption.

Japan has experienced low deflation, although there have been many efforts to stimulate the economy. There are no valid policies for stopping deflation and stimulating a flat economy. Since consumer purchases become very large just before a tax increase, due to hoarding, a tax increase could be used as a valid temporary policy to stimulate the economy and halt deflation<sup>5</sup>.

The consumer’s response to health information has not yet been analyzed<sup>6</sup>. We plan to discuss this in future studies.

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<sup>5</sup>This policy has been proposed by Charles Yuji Horioka at Osaka University since 18 January 2002, see, for example, Horioka (2002a, 2002b).

<sup>6</sup>It is analyzed in detail in Wan (September 2002).

## Appendix A: Proofs for Propositions 3.1 and 3.2

### Proposition 3.1

$P_1 < P_2 = P_3 = \dots P_{T^l}$  is assumed to simplify the proof.

When  $t = T^l$ , according to (3.14),

$$\begin{aligned} \mu_{T^l} &= (1+r)^{-T^l} P_{T^l} - \gamma_{T^l}, \\ I_{T^l} = 0, &\rightarrow \lambda_{T^l} > 0 \text{ (Kuhn - Tucker's condition)} \\ \text{then, } Q_{T^l} &= -I_{T^l-1} + C_{T^l}. \end{aligned} \quad (3.21)$$

according to (3.15),

$$\begin{aligned} \lambda_{T^l} &= (1+r)^{-T^l} F'(I_{T^l}) + (1+r)^{-T^l} P_{T^l} - \gamma_{T^l}, \\ &= (1+r)^{-T^l} P_{T^l} - \gamma_{T^l} > 0 \text{ (Kuhn - Tucker's condition)} \\ \text{then } \gamma_{T^l} &< (1+r)^{-T^l} P_{T^l} \\ Q_{T^l} &> 0, \text{ for } \gamma_{T^l} = 0 \\ Q_{T^l} &= 0, \text{ for } 0 < \gamma_{T^l} < (1+r)^{-T^l} P_{T^l} \end{aligned}$$

Similarly, when  $t=n$ , ( $1 < n < T^l$ ), according to (3.14) and (3.15),

$$\begin{aligned} \mu_n &= (1+r)^{-n} P_n - \gamma_n, \\ \lambda_n &= (1+r)^{-n} F'(I_n) + \mu_n - \mu_{n+1} \\ &= (1+r)^{-n} F'(I_n) + (1+r)^{-n} P_n - (1+r)^{-n-1} P_{n+1} - \gamma_n + \gamma_{n+1}. \\ &\quad (1+r)^{-n} F'(I_n) I_{T^l} \geq 0 \text{ and } \gamma_{n+1} \geq 0, \\ &\quad \text{if } P_n = P_{n+1} \text{ and } \gamma_n = 0, \text{ then } Q_n = 0 \\ &\quad \text{and } \lambda_n > 0, I_n = 0 \\ &\quad \text{if } P_n = P_{n+1} \text{ and } \gamma_n > 0, \text{ then } Q_n > 0 \\ &\quad \text{and } \lambda_n = 0, I_n > 0. \end{aligned} \quad (3.22)$$

### Proposition 3.2

Similarly, when  $t=1$ , ( $1 < n < T^l$ ), according to (3.14) and (3.15),

$$\begin{aligned} \mu_1 &= (1+r)^{-1}P_1 - \gamma_1 = (1+r)^{-1}P_1, \\ \lambda_1 &= (1+r)^{-1}F'(I_1) + (1+r)^{-1}P_1 - (1+r)^{-2}P_2 + \gamma_2. \\ \text{if } 1 < P_2/P_1 &\leq (1+r), \text{ then } \lambda_1 > 0 \text{ and } I_1 = 0, Q_1 = C_1. \\ \text{if } (1+r) < P_2/P_1, &\text{ then } \lambda_1 = 0 \text{ and } I_1 > 0, Q_1 = C_1 + I_1. \\ &\text{and the } I_1 \text{ is the function of } P_2/P_1, F(I_1) \text{ and } T^l, \end{aligned}$$

$$0 \leq I_1^* \leq \sum_{t=2}^{T^l} C_t. \quad (3.23)$$

## Appendix B: Data

**Consumer Price Index**, Statistics Bureau Ministry of Public Management, Home Affairs, Posts and Telecommunications, Japan. *Annual Report on the Consumer Price Index, 1951-1999*.

**Consumer Price Index of Cigarettes**, Statistics Bureau Ministry of Public Management, Home Affairs, Posts and Telecommunications, Japan. “Subgroup Index for Japan”. *Annual Report on the Consumer Price Index, 1951-1999*.

**Nominal Worker Household Disposable Income**, Economic Planning Agency, Government of Japan. *Annual Report of Family Income and Expenditure, 1951-1999*.

**Nominal Retail Cigarette Price**, Statistics Bureau Ministry of Public Management, Home Affairs, Posts and Telecommunications, Japan. “Nation-wide Uniform Prices or Charges” *Monthly Report on the Retail Price Survey, 2000*.

**Nominal Tax Revenues**, Ministry of Finance, Government of Japan. *Public Finance Statistics, 1951-1999*.

**Normal Cigarette Price**, Nominal Retail Cigarette Price (1999) times consumer price index of cigarettes divided by the index (1999).

**Per Capital Worker Household Cigarette Consumption**, Per worker household total cigarette consumption expenditure divided by per household population.

**Real Household Disposable Income**, Nominal Household Disposable Income divided by the consumer price index.

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### 3.7 Figures

### 3.8 Tables



# Chapter 4

## Response to Health Information: Theory and Evidence from Cigarette Consumption and Intake of Nicotine and Tar in Japan

JEL classification: I18, D11, D12; Keywords: rational addiction, smoking, health information, tobacco control

### 4.1 Introduction

Smoking is a complicated behavior. It is influenced not only by price, income, and past and future cigarette consumption but also by many other factors such as health information because it is addictive and harmful to one's health. Therefore, it is very important to clarify how the cigarette consumer responds to health information.

I introduce health information into the rational addiction (RA) model. It is shown that the consumer overconsumes cigarettes because of a shortage of health hazard information and reduces consumption in response to new information.

Precisely because smoking is addictive and harmful to one's health, Japanese government has implemented many tobacco control policies. I use policy in-

formation and Japanese monthly data to test the rational addiction model with health information. The model is strongly supported.

Until now there have been many papers that analyze the consumption of hazardous goods such as cigarettes. Ippolito (1981) developed a theoretical model to analyze consumer reaction to new health information. Ippolito and Ippolito (1984) provided empirical evidence that new health information reduces cigarette consumption. Goldbaum (2000) developed a model which analyzed the consumption path of harmful addictive goods in the continuous time case and concluded that the endogenous desire to quit smoking can result from a rational consumption path chosen as the consumer begins smoking. Viscusi (1992) and Hu, Sung and Keeler (1995) also reported that health hazard information had a strong effect on consumer's behavior. Clark and Etile (2002) find those whose health worsens when smoking smoke less in the future and are more likely to quit using British panel data. But the above papers do not analyze the impact of health hazard information in the context of RA. Here, a testable RA model with health information will be constructed and tested by Japanese policy events and monthly data.

Auld and Grootendorst (2004) point that the estimable RA model tends to yield spurious evidence when aggregate data are used, if, however, prices are exogenous, instrumental variable estimates of the coefficients on the lag and lead of consumption will be consistent. The cigarette consumption in Japan is just the exceptional case. The cigarette price is considered exogenous because it is not determined by cigarette firm but totally by Japanese central government.

There are two papers on cigarette consumption in Japan. One is Haden (1990), which is not concerned with addiction and health hazard information. The other is Yorozu and Zhou (2002) who present a theoretical model of cigarette demand and estimate the model using Japanese prefecture-level data. But there are a few points which need improvement in Yorozu and Zhou (2002). First, the information measure used is prefectural anti-smoking budget dummies which are collected over the telephone from prefectural officials. This budget may be used not only for information dissemination but also for other purposes, for example, the construction of smoking areas (because of smoking ban), etc. Second, the addictive aspect of smoking is ignored and thus there is a specification error in the cigarette demand model. These two points are improved upon in this paper.

The effects of anti-smoking policies (for example, workplace smoking bans) have been analyzed by Evans et al (1999) and Bardsley and Olekalns

(1999), whose results support the view that workplace smoking bans reduce smoking. Wan (2004b) analyzes the effects of Japanese anti-smoking policies using annual data and finds that their effects are not statistically significant<sup>1</sup>. Can these effects be observed when monthly data are used? Wan (2004c) examines the effects of mandatory information disclosure on inter-brand cigarette demands using cigarette brand sales data and finds that the mandatory disclosure of nicotine and tar information decreased the demand of high nicotine and tar brands. Can I confirm these effects by time series data?

This paper is organized as follows: The conceptual framework is described in Section 2. Events of tobacco control are outlined in Section 3. The data and empirical strategy are presented in Section 4. The empirical results are reported in Section 5. I present the conclusions in Section 6.

## 4.2 Conceptual framework

As described in Stigler and Becker (1977), ‘A consumer may indirectly receive utility from a market good, yet the utility depends not only the quantity of the good, but also the consumer’s knowledge of its true or alleged properties. If he does not know whether the berries are poisonous, they are not food, if he does not know that they contain vitamin C, they are not consumed to prevent scurvy.’ The consumer derives utility from a good based on his limited knowledge about it, where knowledge is produced by scientific research and is thus exogenous to the consumer. This idea will be introduced into the Becker, Grossman and Murphy (1994) model. A cigarette demand function with health hazard information will be derived.

Consumers are assumed to be infinite-lived and to maximize lifetime utility discounted at the rate  $r$ . Utility is composed of two parts—one is euphoria from smoking and the other is the disutility from knowing the health hazard. Consumption euphoria and the disutility of the health hazard are assumed to be separable. The consumer’s utility is bounded by their limited information.

$$V(C_t, C_{t-1}, Y_t, e_t; I_t) = U(C_t, C_{t-1}, Y_t, e_t) - \alpha(I_t)C_t. \quad (4.1)$$

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<sup>1</sup>See Wan (2004b).

The consumer's problem is

$$\begin{aligned} \max \sum_{t=1}^{\infty} \beta^{t-1} \left[ U(C_t, C_{t-1}, Y_t, e_t) - \alpha(I_t)C_t \right]. \quad (4.2) \\ \text{s.t. } \sum_{t=1}^{\infty} \beta^{t-1} (Y_t + P_t C_t) = A^0 \\ \beta = 1/(1+r) \end{aligned}$$

Here  $C_t$ ,  $C_{t-1}$  are the quantities of cigarettes consumed in period  $t$  and  $t-1$ , respectively.  $Y_t$  is the consumption of the composite commodity in period  $t$ , and  $e_t$  reflects the impact of unmeasured life-cycle variables on utility. The composite commodity,  $Y$ , is taken as the numeraire, and thus the price of cigarettes in period  $t$  is denoted by  $P_t$ . The rate of interest is assumed to equal the rate of time preference.  $\beta$  is the time discount factor. Any effect of  $C$  on earnings and on the present value of wealth ( $A^0$ ) is ignored. The same applies to the effect of  $C$  on other types of uncertainty. The initial condition for the consumer in period 1,  $C^0$ , measures the level of cigarette consumption in the period prior to the one under consideration.

$\alpha(I_t)$  is the consumer's disutility factor which is his subjective belief that smoking is really harmful to his health. This subjective belief is assumed to increase with *information* by Bayesian leaning framework ; thus  $\frac{d\alpha(I_t)}{dI_t} > 0$ . It is assumed to be zero if the consumer has no health hazard information; in other words,  $\alpha(0) = 0^2$ . New beliefs will be formed when new health hazard information is announced.

The associated first-order conditions are

$$U_y(C_t, C_{t-1}, Y_t, e_t) = \lambda, \quad (4.3)$$

$$U_1(C_t, C_{t-1}, Y_t, e_t) + \beta U_2(C_{t+1}, C_t, Y_{t+1}, e_{t+1}) - \alpha(I_t) = \lambda P_t. \quad (4.4)$$

A consumption euphoria function that is quadratic in  $Y_t, C_t$ , and  $e_t$  is considered. By solving the first-order condition for  $Y_t$  and substituting it into the first-order condition for  $C_t$ , a linear difference equation can be derived,

$$C_t = \theta_0 + \theta C_{t-1} + \beta \theta C_{t+1} + \theta_1 P_t + \eta(I_t) + \theta_2 e_t + \theta_3 e_{t+1} \quad (4.5)$$

---

<sup>2</sup>In the  $\alpha(0) = 0$  case, the model is the same as Becker, Grossman and Murphy (1994).

where <sup>3</sup>

$$\eta(I_t) = \frac{u_{yy}\alpha(I_t)}{(u_{11}u_{yy} - u_{1y}^2) + \beta(u_{22}u_{yy} - u_{2y}^2)}$$

Health hazard information cannot be anticipated by the consumer. If the consumer obtains new health hazard information at time  $t$ , the short-run effect of health hazard information is

$$\frac{dC_t}{dI^*} = \frac{1}{\theta(1 - \phi_1)\phi_2} \frac{d\eta(I_t)}{dI_t} < 0,$$

which is defined as the impact of an increase in current and all future information on current consumption, with past consumption being held constant.

If there is no information depreciation, the long-run effect of health hazard information is

$$\frac{dC_\infty}{dI} = \frac{1}{\theta(1 - \phi_1)(\phi_2 - 1)} \frac{d\eta(I_t)}{dI_t} < 0$$

which is defined as the effect of a permanent increase in information in all periods.

$|\frac{dC_\infty}{dI}| > |\frac{dC_t}{dI^*}|$ , meaning that the absolute value of the long-run effect is larger than the short-run one.

True information on smoking damage can be called  $I_{max}$ . If the information  $I$  received by the consumer is smaller than  $I_{max}$ , the consumer will overconsume cigarettes.  $C(I) > C(I_{max})$  for  $I_{max} > I$ .

### 4.3 Events

There were ten main events of tobacco control during the 1951-99 period. They are shown in Table 4.1. How did consumers respond to these events?

<sup>3</sup>There seems to be a misprint in Becker, Grossman and Murphy (1994). According to my calculations, the last multiplicative term in the numerator of the formula for  $\theta_3$  should be  $u_{2y}u_{ey}$  instead of  $u_{2y}u_{2e}$ .

$\theta_0 = -\lambda(u_{y1} + \beta u_{y2})$ ,  $\theta = \frac{-(u_{12}u_{yy} - u_{1y}u_{2y})}{(u_{11}u_{yy} - u_{1y}^2) + \beta(u_{22}u_{yy} - u_{2y}^2)}$ ,  $\theta_1 = \frac{u_{yy}\lambda}{(u_{11}u_{yy} - u_{1y}^2) + \beta(u_{22}u_{yy} - u_{2y}^2)}$ ,  $\theta_2 = \frac{-(u_{yy}u_{1e} - u_{1y}u_{ey})}{(u_{11}u_{yy} - u_{1y}^2) + \beta(u_{22}u_{yy} - u_{2y}^2)}$ ,  $\theta_3 = \frac{-\beta(u_{yy}u_{2e} - u_{2y}u_{ey})}{(u_{11}u_{yy} - u_{1y}^2) + \beta(u_{22}u_{yy} - u_{2y}^2)}$ . A good is addictive if  $\theta > 0$ , and the degree of addiction increases with  $\theta$ . The roots of the difference equation are  $\phi_1 = \frac{1 - (1 - 4\theta^2\beta)^{1/2}}{2\theta}$ ,  $\phi_2 = \frac{1 + (1 - 4\theta^2\beta)^{1/2}}{2\theta}$ , and the stability conditions are  $4\theta^2\beta < 1$ ,  $\phi_1 < 1$ ,  $\phi_2 > 1$ . The short-run and long-run price effects are  $\frac{dC_t}{dP^*} = \frac{\theta_1}{\theta(1 - \phi_1)\phi_2}$ ,  $\frac{dC_\infty}{dP} = \frac{\theta_1}{\theta(1 - \phi_1)(\phi_2 - 1)}$ . See Becker, Grossman and Murphy (1994) for details.

Have they effectively contributed toward reducing cigarette consumption? Dummy variables were constructed from the information shown in Table 4.1 and included in our econometric model.

There were six events of tobacco tax increases. They are shown in Wan (2004a). To control for hoarding just before tax increases, dummy variables relating to the tax increases were used in the following econometric analysis.

## 4.4 Data set and empirical strategy

### 4.4.1 Data set used in econometric analysis

All of the data used consist of monthly time series from Jan. 1951 to Oct. 1999. They are described in details in Appendix A. Table 4.2 presents means, standard deviations and other descriptive statistics for the variables (after seasonal adjustment) in the data set.

### 4.4.2 Empirical strategy

#### Unit root tests

If any of variables are not stationary, some problems of statistical inference would arise if ordinary least-squares (OLS) or generalized methods of moments (GMM) were used. Therefore, we test whether each variable is stationary. The ADF test and Phillips-Perron test (1988) are used (see Table 4.3).

The null hypothesis that  $C_t$ ,  $P_t$ ,  $\Delta Y_t$  and  $Tax_t$  have unit roots are rejected the 1% significance level, so these variables are considered to be stationary. Since the null hypothesis that  $Y_t$  has a unit roots cannot be rejected at any conventional significance level,  $Y_t$  is not stationary. When  $Y_t$  is included and OLS and GMM are used, a bias may arise, thus I use the  $\Delta Y_t$ . *Nicotine intake<sub>t</sub>* and *Tar intake<sub>t</sub>* are stationary with time trend, thus a time trend should be included in the estimation equation.

#### Estimation technique

OLS and GMM are used to obtain parameter estimates. OLS is used to estimate the non-addiction model. Because there is serial correlation in the residuals, AR(1) model is used to estimate non-addiction model. In the case

of the addiction model, the OLS estimates may not be consistent because of the endogeneity of past and future consumption and because of the possibility that the use of leads and lags gives rise to serial correlation in the residuals. To obtain consistent estimates I use GMM.

The GMM estimates will be consistent if instrument variables are used. Cigarette prices are totally controlled by the Japanese government, so they are exogenous from the the point of view of consumers. Furthermore, since prices are strongly correlated with consumption, they are thought to be good instrument variable for consumption. The lagged cigarette price is used as an instrument variable for past cigarette consumption, while the lead of price is used as an instrument variable for future cigarette consumption. The leads and lags of the rate of tobacco tax increase are also included as additional instruments. Hansen's (1982)  $J$  test of the overidentifying restrictions implied by the instruments is used as a portmanteau specification test of the model.

To obtain consistent estimates, the hoarding and stock proxies are used to distinguish purchases from consumption following Wan (2004a).

## 4.5 Results

### 4.5.1 Cigarette consumption

#### Results from estimation

The parameter estimates of the rational addiction model are reported in Table 4.4. The non-addiction model (Model 1) is estimated by OLS. The RA models (Models 2 and 3) are estimated using GMM.

In the columns for Models 2 and 3, the coefficients of  $C_{t-1}$ ,  $C_{t+1}$  are positive and significant. The coefficient of  $P_t$  is negative and significant. The estimated values satisfy the stability conditions. Thus these results soundly support the RA model.

The coefficient of  $\Delta Y_t$  is not significant in Model 2, also is not significant in Model 3.

The coefficient of *US Report* is positive but not significant.

The coefficients of *Nicotine-tar* and *Warning1* are positive and significant. It appears that the consumer maintains or increases her consumption of cigarettes but shifts to low nicotine and tar types of cigarettes after information on nicotine and tar is disclosed, because the total intake of nicotine

and tar decreased significantly. It is clarified in the next subsection ‘Nicotine and tar intake’. See the Figures 4.1, 4.2 and 4.3 and the results in Table 4.7.

The coefficient of *Workplace* is negative and significant. Thus, the policy of a smoking ban was effective. This result is different from the results based on annual data.

The coefficient of *Research* is negative and significant. Thus, cigarette research has a negative effect on cigarette consumption, as expected.

The coefficients of *Report1* and *Warning2* are negative and significant. This result can be interpreted as follows: the consumer decreases the consumption in response to the disclosure of damage information. According to Figures 4.2 and 4.3, average nicotine and tar per cigarette declined only slightly and was very stable after the 1980’s. The consumer had to reduce consumption in order to adjust the stock of nicotine and tar gradually in response to new health hazard information. This behavior is also consistent with RA behavior.

The coefficient of *Report2* is negative, as expected, but not significant.

The coefficient of *Hoarding* is positive, significant and large, while the coefficient of *Stock* is negative, significant and large. Thus the consumer hoarded many cigarettes just before the price increase taking account of future price information. This result is very close to the one in Wan (2004).

In the RA model, consumption depends on past and future consumption, thus it changes only gradually. Thus, there is a possibility that the RA model makes it difficult for the consumers to respond in a timely manner to health information. I also tried estimating a standard model (Model 1), but its results were very close to those of the RA model.

The consumers’ responses to information on price and health suggest that she is very rational.

I also use the estimated coefficients and sample means in Table 4.2 to estimate the short-run and long-run price elasticities<sup>4</sup>, which are shown in

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<sup>4</sup>The results in this paper are different from Haden (1990). The price and income elasticities of Japanese cigarette consumption are estimated by Haden (1990) using annual data for 1964-83. Haden estimates the income elasticity to be 0.161 and the price elasticity to be  $-0.948$ . Thus, cigarette is a normal good. The results in this paper are also different from those of Yorozu and Zhou (2002). They estimate the income and price elasticities of demand for cigarettes to be 0.291 and  $-0.986$ , respectively. According to Gruber and Köszegi (2001), the long-run price elasticity in the U.S. (based on monthly data) is  $-0.8$ , while we estimate the long-run price elasticity in Japan to be  $-0.524$ . Thus, the absolute value of the long-run price elasticity is somewhat smaller in Japan than in the U.S.



the rows labeled ‘short-run  $\epsilon$ ’ and ‘long-run  $\epsilon$ ’. The long-run price elasticity is about 2.055 times as large as the short-run price elasticity and is close to the estimate based on annual data<sup>5</sup>.

The value of  $\beta$  implied by the results in the Table 4.4 is too small. It is considered difficult to estimate  $\beta$  precisely using a specific good. Here I impose the discount factor a priori to estimate the RA model (Model 2) again. The long-run price elasticities are reported in Table 4.5.

The results in Table 4.5 are stable when  $\beta$  is changed from 0.4 to 0.95 and are very close to the those of Model 2 in Table 4.4.

### **Rate of contribution of each factor**

Cigarette purchases data showed an upward tendency during the Jan. 1951-Mar. 1975 period, but a downward trend during the Apr. 1975-Oct. 1999 period. Thus, I divide the full period into two subperiods and estimate the cigarette demand model separately<sup>6</sup>. The coefficient of  $Y_t$  is significantly positive during the Jan. 1951-Mar. 1975 period but is significantly negative during the Apr. 1975-Oct. 1999 period. The various estimates are used to calculate the rate of contribution of each factor. The rate of contribution of price, income and other factors are shown in Table 4.6.

About 57.4% of the increase in cigarette consumption during the Jan. 1951-Mar. 1975 period can be explained by the decline in real price, about 17.4% by the disclosure of nicotine and tar content, about 16.2% by ‘Warning1’ and about 9.0% by other factors.

About 28.9% of the decrease in cigarette consumption during the Apr. 1975-Oct. 1999 period can be explained by the increase in real price, about 12.4% by the ‘Workplace ban’, about 19.6% by ‘Research’, about 17.4% by ‘Report1’, about 13.6% by ‘Warning2’ and about 8.1% by other factors. Therefore, the total contribution rate of all tobacco control policies during the Apr. 1975-Oct. 1999 period is about 63.0% which is bigger than that of tax or price increase.

### **4.5.2 Nicotine and tar intake**

I have not the nicotine and tar price, so I can not estimate the RA model using nicotine and tar intake. I use the cigarette price as the proxy for the

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<sup>5</sup>The long-run elasticity is about  $-0.67$ , see Wan (2004b).

<sup>6</sup>A Chow test is performed and the structural change is confirmed.

price of nicotine and tar and estimate the intake of nicotine and tar by OLS. The error term is assumed to be AR(1). The results are reported in Table 4.7.

In the column for nicotine intake, the coefficient of  $P_t$  is significantly negative and the price elasticity is -1.126. The hoarding is significantly positive and the stock is significantly negative. The coefficient of *Nicotine-tar* is significantly negative. It implies that the release of nicotine and tar content significantly decreases the intake of nicotine. The other variables are not significant.

In the column for tar intake, the coefficient of  $P_t$  is significantly negative and the price elasticity is -1.110. The hoarding is significantly positive and the stock is significantly negative. The coefficient of *Nicotine-tar* is significantly negative. It implies that the release of nicotine and tar content significantly decreases the intake of tar. The other variables are also not significant.

From Figures 4.1, 4.2 and 4.3, it is clear that structural change<sup>7</sup> of nicotine and tar intake took place in the middle of 1960's, when US report and release of nicotine and tar content were implemented.

These results are consistent with those of cigarette consumption, and also consistent with those in Wan (2004c).

### 4.5.3 Robust results from survey data

There are some surveys about smoking and health information in Japan<sup>8</sup>. The samples of the various surveys are assumed to be binomial distributions. Difference tests are used to test whether there are differences about information on the damage from smoking between earlier and later surveys and among smokers, former smokers and non-smokers.

#### **Information on the damage from smoking has increased with time**

There were two surveys that collect information on the damage from smoking<sup>9</sup>. The proportions of those who know about the damage from smoking are

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<sup>7</sup>A Chow test is also performed and the structural change is confirmed.

<sup>8</sup>See Appendix B for details.

<sup>9</sup>The wording of the questions about the information on damage from smoking is very similar, even though these two surveys were conducted by two different institutions and in different time.

summarized in Table 4.8. In Table 4.8, the values in the ‘difference’ column indicate the increase in the proportion of those who knew about the damage from smoking. All the values are positive and significant; thus, information on smoking damage has increased over time.

### **Difference in the awareness of the damage from smoking between smokers and non-smokers**

In Table 4.9, the values in the ‘difference’ column indicate the gap between smokers and non-smokers in the proportion of those who knew about the damage from smoking. In the 1978 survey, only two values are significant, but in the 1999 survey, all values are significant and positive. Thus, there was an information gap between smokers and non-smokers, especially in 1999. One of the interpretations of this result is that non-smokers did not smoke because they were more aware of the damage from smoking than smokers.

### **The reasons for quitting or reducing smoking**

Smokers’ reasons for quitting or reducing smoking are shown in Table 4.10<sup>10</sup>. The most important reason is ‘harmful to health’ in every year. The change in the importance of the health reason during the 1981-1988 period was bigger than during the 1988-1999 period. This implies that there was a sharp increase in the amount of smoking damage information during the 1981-1988 period.

The second most important reason changed over time. The cost reason was relatively unimportant and increased little in importance during the 1981-1988 period due to the relatively low real price of cigarettes and to the bubble economy. By contrast, the cost reason increased sharply in importance during 1988-1999 due to the relatively high real price of cigarettes that resulted from the tax increase and to the Japanese depression (in Japanese, Heisei Fukyo).

The results shown in Table 4.10 are consistent with the ones in the econometric analysis in the previous sections.

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<sup>10</sup>The reasons why former smokers for quit or reduced smoking are not shown here. The reasons are very similar to those why smokers want to quit.

## 4.6 Conclusion

Auld and Grootendorst (2004) point that the RA model tends to yield spurious evidence when aggregate data are used, if, however, prices are exogenous, instrumental variable estimates of the coefficients on the lag and lead of consumption will be consistent. The cigarette consumption in Japan is just this case, because the cigarette price is not determined by cigarette firm but totally by Japanese central government thus the price is considered exogenous. The RA model with health information is strongly supported by monthly data for Japanese salaried worker households and several policy events. Information on smoking damage has increased with time. The consumer responds to the increase in health information by changing cigarette type, quitting or reducing smoking.

The share of filter cigarettes has been increasing since the 1960's due to information disclosure in the U.S. and Japan. The amount of nicotine and tar per cigarette has decreased continuously since data on nicotine and tar was released in 1967. The intake of nicotine and tar was significantly decreased by the release of nicotine and tar content.

I also get robust evidence from national smoking surveys in Japan. There are information gaps between smokers and non-smokers. Non-smokers have more information on smoking damage than smokers. Because health reason is the most important one why smokers quit or reduce smoking, it is a good idea for tobacco control to give smokers more information about health damage.

Tobacco control policies for example, workplace smoking bans, smoking science research, health warning, nicotine labeling, etc. were shown to be effective in reducing smoking. About 28.9% of the decrease in cigarette consumption during the Apr. 1975-Oct. 1999 period can be explained by changes in real prices, about 63.0% by tobacco control policies such as workplace smoking ban, health information disclosure. These results are also consistent with the data from one of Japan's national smoking surveys. For tobacco control, therefore, the provision of health information is much more effective than the tax or price increase.

The welfare change arising from increased price and health information is not analyzed in detail in this paper. It is hoped that these issues will be resolved in the future.

## Appendix A: Statistical data

**Cigarette purchase by Japanese worker households**  $C_t$  is cigarette purchase in packs per capita per month. The data are taken from ‘Annual Report of Family Income and Expenditure Survey.’ The data are purchase data and this was taken into account by using hoarding and stock dummies. The data were seasonally adjusted using X-12 ARIMA.

**Nicotine intake**  $Nicotine\ intake_t$  is the monthly intake of nicotine in mini gram per capita. The data are made by multiplying cigarette purchase by nicotine content per cigarette. The nicotine intake from filter cigarette is adjusted by multiplying 50 percent compared to that from non-filter cigarette according to ‘The History of Tobacco Monopoly’. The data were seasonally adjusted using X-12 ARIMA.

**Tar intake**  $Tar\ intake_t$  is the monthly intake of tar in mini gram per capita. The data are made by multiplying cigarette purchase by tar content per cigarette. The tar intake from filter cigarette is adjusted by multiplying 50 percent compared to that from non-filter cigarette according to ‘The History of Tobacco Monopoly’. The data were seasonally adjusted using X-12 ARIMA.

**Price**  $P_t$  is the real average retail cigarette price per pack in each month. It is equal to the Tobacco Price Index divided by the Consumer Price Index (CPI). These data are from the ‘Annual Report on the Consumer Price Index’ and the ‘Monthly Report on the Retail Price Survey.’ They were seasonally adjusted using X-12 ARIMA.

**Disposable income**  $Y_t$  is real per capita salaried worker household disposable income per month. These data are from the ‘Annual Report of Family Income and Expenditure Survey.’ It was calculated by dividing average household disposable income by the average number of household members per household and the CPI. The data were seasonally adjusted using X-12 ARIMA.

**Tax Rate**  $Tax_t$  is the rate of tax increase. The data are from ‘Public Finance Statistics.’

**US Report** is a dummy variable relating to the release of ‘Smoking and Health: Report of the Advisory Committee to the Surgeon General of the Public Health Service’ in 1964 in the U.S. It has a value of 0 from Jan. 1951 to Dec. 1963 and a value of 1 from Jan. 1964 to Oct. 1999.

**Nicotine and tar** is a dummy variable relating to the release of nicotine and tar information. It has a value of 0 from Jan. 1951 to Mar. 1967 and a

value of 1 from Apr. 1967 to Oct. 1999.

**Warning1** is a dummy variable relating to the warning ‘Let’s be careful about smoking too much for health reasons.’ It has a value of 0 from Jan. 1951 to Jul. 1971 and a value of 1 from Aug. 1971 to Oct. 1999.

**Dummy7504** is a dummy variable for the period from Apr. 1975 to July 1975. It has value 1 from Apr. 1975 to July 1975 and a value of 0 in all other periods. The tax increase proposal was passed by the Finance Committee on 24 Apr. 1975 but it was voted down by the Lower House on 4 Jul. 1975.

**Dummy7509** is a dummy variable for the period from Sept. 1975 to Nov. 1975. It has value 1 from Sept. 1975 to Nov. 1975 and a value of 0 in all other periods. The tax increase proposal was submitted to the Diet again on 20 Sept. 1975 and was enforced on 18 Dec. 1975.

**Workplace** is a dummy variable for smoking bans. It has a value of 0 from Jan. 1951 to Mar. 1978 and a value of 1 from Apr. 1978 when the smoking ban on hospitals, etc., was mandated to Oct. 1999.

**Research** is a dummy variable for smoking research. It has a value of 0 from Jan. 1951 to Mar. 1986 and a value of 1 from Apr. 1986 when the Smoking Research Foundation was established to Oct. 1999.

**Report1** is a dummy variable for the 1st edition of ‘Report on Smoking and Health.’ It has a value of 0 from Jan. 1951 to Sept. 1987 and a value of 1 from Oct. 1987 when the report was released to Oct. 1999.

**Warning2** is a dummy variable relating to the warning ‘Let’s be careful about smoking too much because there is a possibility it will ruin your health.’ It has a value of 0 from Jan. 1951 to Dec. 1989 and a value of 1 from Jan. 1990 when the warning was mandated to Oct. 1999.

**Report2** is a dummy variable for the 2nd edition of ‘Report on Smoking and Health.’ It has a value of 0 from Jan. 1951 to May 1993 and a value of 1 from Jun. 1993 when the report was released to Oct. 1999.

**Hoarding** is a dummy variable for months just before cigarette tax increases. According to Wan (2004a), the lead of  $Tax_t$  is a valid proxy for *Hoarding*.

**Stock** is a dummy variable for months immediately after cigarette tax increases. According to Wan (2004a),  $Tax_t$  is a valid proxy for *Stock*.

## **Appendix B: Surveys**

### **1978 Survey on Smoking**

An opinion poll on smoking was conducted by the Mainichi Shimbun Corporation in April 1978. 2,176 pollees were randomly chosen from among persons aged 20 and over in Japan, and they were interviewed by the polltakers. The response rate was 73%. The smoking rate of adult males was 75% and that of adult females was 13%. These results are broadly consistent with the results of the JT survey, in which the male rate was 74.7% and the female rate was 16.2%. Respondents were asked the following question. ‘What do you regard as the harmful effects of smoking?’ There were 12 items from which to choose and more than one could be chosen.

### **1981 National Survey on Smoking**

This survey (in Japanese, Kitsuen ni Kansuru Zenkoku Ishiki Chosa) was conducted by Tadao Shimao who was the chief researcher in the Research Institute of Tuberculosis Japan Anti-Tuberculosis Association in 1981. 5,394 adult persons, who were the families or friends of members of the 47 branches of the Japan Anti-Tuberculosis Association in all prefectures were surveyed. The survey period was from Feb. 1981 to Mar. 1981. A self-registering paper questionnaire method was used. There were 2,933 male respondents (54.3% of the total) and 2,461 female respondents (45.6% of the total). The male and female share in the total population were 49.2% and 50.8%, respectively, in Oct. 1980.

### **1988 Survey on Smoking and Health**

This survey (in Japanese, Kitsuen to Kenkou ni Kansuru Yoron Chosa) was conducted by the Public Relations Office of the Prime Minister’s Office Japan during the October 27-November 6, 1988, period. 2,339 persons aged 20 and over were surveyed. They were selected from throughout Japan using a two-stage stratified random sampling method. The response rate was 78.0%. The survey method used was direct interviewing of respondents.

## **1999 National Survey on Smoking and Health**

This survey was conducted by the Ministry of Health and Welfare of Japan during the February 17-March 2, 1999, period. 12,858 persons aged 15 and over were surveyed. They were randomly selected from the sample used for the 1998 'Basic Survey on National Life' in fiscal year 1998. The response rate was 91.9%. The survey method was direct interviewing of respondents. The smoking rate of adult males was 52.8% and that of adult females was 13.4%. These results are very close to those of the JT survey, in which the male rate was 55.2% and the female rate was 13.3%. Respondents were asked the following question: 'What do you regard as the harmful effects of smoking?' There were 8 answers from which to choose and more than one could be chosen.



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## 4.9 Figures

## 4.10 Tables

# Chapter 5

## Responses of Consumers to the Mandatory Disclosure of information: Evidence from Japanese Inter-brand Cigarette Sales

JEL classification: I18, D12, D82; Keywords: inter-brand cigarette, nicotine, tar, mandatory disclosure

### 5.1 Introduction

Whether there is a need for the mandatory disclosure of information continues to be hotly disputed. Many economists insist, by means of theoretical analyses, that mandatory disclosure is necessary, and much empirical evidence supports this view. However, some economists do not accept this claim and strong evidence has recently been provided that undermines the idea that more information is better<sup>1</sup>. Thus, clarification of which side of the debate provides the most accurate description of reality is still needed and has important implications for policymaking and legislation. This study provides new evidence that mandatory disclosure decreases tar intake, increases consumer welfare, and makes monopolistic firms improve product quality.

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<sup>1</sup>See details in Dranove, Kessler, McClellan and Satterthwaite (2003).

A new empirical technique for testing the effect of mandatory information disclosure, which makes use of a difference-in-difference (DID) approach, is also provided for directly estimating those changes in inter-brand cigarette demands resulting from policy changes and increased information awareness about nicotine and tar content levels.

Another aim of this research was the provision of relevant evidence in support of the recent legislation and legal changes regarding information disclosure in Japan. Scholars, consumers, and policy makers have begun to voice concerns regarding issues related to information disclosure. For example, the disclosure of information regarding genetically recombinant food has recently become a hot topic, both globally and in Japan. As a result, the Democratic Party submitted the 'Food Safety Proposal' to Parliament on March 29, 2002. Article Five of this Law specifies "an entrepreneur's duty" as comprising the obligation of economic agents to display warning or caution labels on food products, to perform quality checks during production, and to provide appropriate product information and warnings; this "duty" includes the country's or the local organizations' obligation to support producers in the process of safe product storage. Though the "Food Safety Proposal" is currently being discussed, the key question here is whether this proposal is really warranted; that is, whether consumers have enough information already about food without the need for additional labeling.

In addition, proper labeling concerning the quality of agricultural and forestry products is specified in the JAS Law (the law related to the standardization and suitability of product quality information for agricultural and forestry materials). Standards for consumer information, as well as penalties in the event of their violation, have been amended recently. Furthermore, new standards concerning fresh or perishable food have been enforced since July 1, 2000, and new standards for processed and genetically recombinant food took effect on April 1, 2001. In addition, some penalties for violations of consumer information standards have been increased. Under the new law, an individual perpetrator faces up to one year in prison or up to one million yen in fines (previously the penalties involved no imprisonment and up to 0.5 million in fines). In the case of an organization, the maximum penalty is now 100 million yen, as compared with a mere 0.5 million previously. Further legal regulations include the Food Sanitation Law and the Product Liability Law.

Whether the product information provisions regulated by such laws have any effect is related to three issues. The first relates to the extent to which

sellers disclose information about their products, the second is the question of how consumers react to newly released information, and the third is the issue of whether sellers improve the quality of their products in response to the mandatory disclosure of information. It is crucial, therefore, to test these issues empirically<sup>2</sup>. However, it is very difficult to measure the effect of information disclosure, for two main reasons. First, the abstract and broad character of information make it difficult to quantify and to define. Second, it is hard to separate the effects of information disclosure from the effects of other factors. For example, even if some information is presented and has an effect, the economy always changes, and thus any effect is mixed with those of other factors in creating the final effect. As a result of these problems, research on information disclosure is rare, in general, and has been virtually non-existent in Japan.

This paper proposes a new method for verifying the effects of information disclosure. Using cross-sectional time-series data, I investigated consumers' responses to public information announcements. Since they responded to the newly disclosed information, this implies that they originally had insufficient information. On the other hand, an absence of a statistically significant consumer response could have meant that the amount of information previously available was sufficient or that the disclosure of information had no effect, or both. I also analyzed the behavior of a monopolistic firm during the periods of voluntary disclosure and mandatory disclosure.

Clarification of the ways in which information disclosure has influenced changes in the demand for cigarettes of various brands is important for several reasons. It is widely known that cigarettes are an addictive good and that it is difficult to give them up. The drug heroin is said to be the most addictive good; it is closely followed, however, by cigarettes and alcohol. The degree of addiction induced by general goods, such as instant juice or vegetables, is considered to be low or close to zero. Furthermore, it is commonly believed that consumers' responses with regard to addictive goods are less sensitive to exogenous information shock than is the case with general goods, as the consumer cannot easily give up addictive goods or find substitutes. Therefore, in the event of a statistically significant effect of information disclosure on the consumption of the addictive good tobacco, we might conjecture that there is a similar, but stronger, effect on the consumption of general goods.

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<sup>2</sup>An analysis of the aggregate demand for cigarettes in Japan as a response to health information is presented in Wan (2004c).



In this study, I present the results of a “natural experiment”, comprised of an empirical test that distinguished information disclosure effects from other effects. Specifically, I estimated the effect of information disclosure by examining several different consumer groups, i.e., treatment groups with various levels of consumer information disclosure impact, and control groups that received little or no information. Moreover, I performed difference tests to demonstrate the impact of mandatory disclosure on a monopolistic firm.

The composition of the paper is as follows. Section 2 reviews previous research. Section 3 introduces the present state of information disclosure in Japan. Section 4 describes events. Section 5 presents the data and a detailed description of the problems encountered and explains the empirical strategies and solution techniques used. Section 6 shows the model and estimation techniques. Section 7 reports the estimation results. Finally, Section 8 concludes and discusses issues relevant to future research.

## **5.2 Previous Research**

### **5.2.1 Theoretical Research**

Very few theoretical research papers have been written on the topic of information disclosure. The most influential works have been Grossman (1981) and Milgrom (1981). Grossman (1981) analyzed a seller’s behavior with regard to information disclosure. In his model, a buyer does not know the quality of goods on the market, while a monopolistic seller knows both the quality of its goods and the buyer’s preferences. The seller decides on a strategy with regard to how much information to disclose. Furthermore, it is assumed that the cost to the seller of information disclosure is zero and that the buyer can confirm whether the disclosed information is true or false without cost after purchasing the good (for example, the consumer might wish to verify the advertised weight of a diamond). It is also supposed that, although the buyer believes in the validity of any disclosed information, he or she may have some doubts concerning any remaining undisclosed information, possibly because of the good’s poor quality. In this setting, the optimal strategy of the seller is to completely disclose all information. Furthermore, one can also consider the seller’s costs of information disclosure and customer persuasion (the seller’s explanation and persuasion costs), and the cost to the buyer of confirming the information after purchase (for instance, it takes time for the

buyer of a used car to evaluate the real status of the car). Within such a framework, and with no moral hazard (e.g., the buyer does not deliberately destroy the car), the optimal strategy of the seller is to completely disclose all information and to provide the buyer with complete quality assurance. Mandatory disclosure is thus not needed, because it is in the interests of the firm to disclose all information voluntarily.

Verrechia (1983) introduced a nonzero information disclosure cost into the standard model. In his paper, a seller does not choose the formerly unique solution of full disclosure when there are costs associated with this disclosure (for example, the cost of information dissemination or the benefits of such information to a hostile enterprise). The seller instead chooses to disclose information only when the profits from such a decision exceed the costs. More recently, several papers have researched information disclosure. For example, Fishman and Hagerty (2003) have pointed out that in certain situations mandatory disclosure might be worse than voluntary disclosure. In short, there is still no consensus in the theoretical literature as to whether mandatory or voluntary disclosure is better.

## 5.2.2 Empirical Research

Some empirical work has suggested that information disclosure influences consumption in the USA. One paper analyzed the effect on egg and food oil consumption patterns of information about cholesterol's negative impact on health. Brown and Schrader (1990) demonstrated that health information influenced the consumption of eggs. The accumulated yearly number of articles espousing either of two opposing viewpoints (that cholesterol is either good or bad for the health) published in medical magazines between 1955 and 1987 was indexed as a measure of information. Time-series for the period from 1955 to 1987 were used to show that the dissemination of information suggesting that cholesterol was bad for the health brought about a significant reduction in egg consumption. Furthermore, the introduction of health information empirically helped to explain the phenomenon that egg consumption in America decreased, despite a decline in the price of eggs.

Yen and Chern (1992) investigated the consumption of seven kinds of animal and vegetable oils using time-series data for the period from 1950 to 1980 and the cholesterol index of Brown and Schrader (1992) as a proxy variable for health information. Their empirical result was that the consumption of animal oil was reduced, and that vegetable oil consumption significantly

increased as a result of the disclosure that cholesterol is bad for the health. Chern, Loehman, and Yen (1995) verified the effect of health information on consumption by using data similar to that of Yen and Chern (1992). The averages and variances of consumers' beliefs were used as proxy variables for information measures, in accordance with the Bayesian information model. They used data on the percentage of people who believed that cholesterol is bad for the health, derived from a survey carried out by the American Food and Medical Administration Office, as well as the cholesterol index of Brown and Schrader (1992). Their results were consistent with those of Yen and Chern (1992).

Ippolito and Mathios (1995) also provided evidence that the dissemination of information on the negative effects of cholesterol had an impact on food consumption. In the context of their paper, producers' food packaging and advertisements were either free or costly, though the causalities between oil (cholesterol) and sickness had been presented to the general public between 1977 and 1985, with the government as the general source of information. Regulation of producers' food packaging and advertising was enacted between 1985 and 1990. The authors verified that these regulations had had an impact on consumption by examining the survey data (1977, 1985, 1986, 1987, 1988, 1989 and 1990) for 48 states, provided by the American Agricultural Ministry. The consumption of low-fat foods, such as cereals, increased significantly, while the consumption of high-fat foods, such as meat and eggs, decreased significantly.

Furthermore, Alan D. Mathios (2000) examined nutrition label information and supermarket scanner data before and after the introduction of the Nutrition Labeling and Education Act and found that mandatory labeling had had an impact on consumers' behavior and health. However, Dranove, Kessler, McClellan and Satterthwaite (2003) provided evidence that public disclosure of patient outcomes had decreased patient and social welfare. Jin and Leslie (2003) presented a new approach for analyzing the effect of an increase in the product quality information provided to consumers on a firm's decisions regarding product quality. They used restaurant hygiene grade cards as the measure of information disclosure and provided evidence that these grade cards caused restaurants to make hygiene quality improvements, although they could not directly estimate the demand for restaurant food, due to the lack of each restaurant's price information.

This paper differs from that of Jin and Leslie (2003) in three main respects. First, the estimation approach adopted directly estimated demand

by means of disclosed information rather than by means of estimated revenue. Second, it focuses on the behavior of a monopolistic firm in response to mandatory information disclosure, whereas Jin and Leslie (2003) focused on relatively competitive firms (restaurants) under both mandatory and voluntary disclosure. Third, this paper focuses on an addictive good (cigarettes), whereas this was not the case in Jin and Leslie (2003).

Viscusi (1992) analyzed the effect of the disclosure of the information that smoking is harmful to the health on smoking behavior, using American survey data. He found that the probability that an informed person would smoke was lower than that for an uninformed one. Furthermore, the introduction of such information significantly decreased cigarette consumption. Yorozu and Zhou (2002) and Wan (2002c) analyzed the effect of information dissemination on cigarette consumption in Japan. Yorozu and Zhou (2002) used prefectural sales data and a prefectural dummy based on whether there was a smoking and health advertising budget as measures of information dissemination, in order to verify the effect of increased information on cigarette consumption. Consumption in the prefectures that had a budget for advertising decreased significantly. Along similar lines, Wan (2002c) used monthly data and event dummies to analyze the effect of information on total consumption and concluded that information regarding the damage potentially caused by smoking reduced consumption significantly.

In previous research, advertisements, regulations and opinion polls, were used as measures of information. By contrast, I used not only policy information, such as regulation, but also the contents of goods, as measures of information in my analysis. The measures of information discussed in this paper are reliable, and the measurement bias of this information is low. Furthermore, the estimation approach used in this paper differs significantly from those used in previous research in that I used inter-brand demand directly, by means of a DID approach. Although much research related to cigarette consumption has been conducted using both macro and micro data, there has been no analysis conducted, to date, of the way in which nicotine and tar content information disclosure has impacted inter-brand cigarette demand by causing consumers to switch products. This inquiry is thus the first of its kind.

### 5.3 Present State of Information Disclosure in Japan and the Theory of Information Disclosure

It is a matter of established fact that not only in the past but also in the present the Japan Tobacco & Salt Public Corporation (JT) and other Japanese food makers have been unwilling to disclose full information about the quality of their products. This can be explained by means of the information disclosure theory.

In the case of Japanese cigarette consumption, it is very costly for a consumer not to obtain information about cigarette quality (such ignorance might cost one one's life). In addition, as insisted in Grossman (1981), it is possible that, in the presence of moral hazard, the options of full information disclosure and offering a complete guarantee for the goods are not chosen. This may be why the JT, a monopolistic supplier, does not voluntarily choose to disclose full information or to provide complete guarantees for its products (for instance, by offering compensation if the consumption of its product has a harmful impact on the health of consumers). Consistent with the results of the Verrechia (1983) model, the JT has not disclosed information whenever such information has been unfavorable. Thus, one may take the position that the Ministry of Finance should coerce the JT to disclose information regarding its cigarettes in order to improve the welfare of cigarette consumers.

The fact that this Japanese food maker does not want to disclose full information voluntarily can be explained by the costs of information disclosure that arise for both the seller and the buyer. For example, although genetically recombinant food differs little from ordinary food in its taste, it is thought that it might be more dangerous than common food. At this time, due to technical limitations and costs, it is impossible for a consumer to check whether a particular food item is genetically recombinant. Moreover, if there is no government regulation in this area, the seller must incur an enormous cost to prove to the buyer that the food he or she sells is not genetically recombinant.

Therefore, because of the enormous costs of information disclosure and verification, the government must legislate information disclosure and establish organizations for information verification (for example, various governmental inspection sections). In addition, a substantial tax should be charged to cover costs; information disclosure on the part of sellers should be enforced

and the government, in accordance with appropriate laws, should examine the information disclosed by sellers for validity.

## 5.4 Policy Events Regarding Smoking in Japan

Three policy events pertinent to smoking in Japan were used to measure information quantitatively. The first occurred on February 6, 1964, when the Ministry of Health and Welfare of Japan sent for dissemination “A Notice about Health Damage from Smoking” to prefectural governors and to the mayors of several designated cities, as a result of the influence of the U.S. “Smoking and Health Report”, published in 1964. We may consider this to be a kind of completely exogenous shock to the consumer, as the government, for the first time, officially informed consumers about the negative health effects of smoking.

The second information disclosure event in Japan concerned the nicotine and tar content of cigarettes. In 1967, the amounts of nicotine and tar per cigarette were published in the newspapers, on the instructions of the Ministry of Finance. We can also consider this event as constituting a completely exogenous information shock, for the following reason. Before this disclosure, neither consumers nor the JT possessed information about nicotine and tar levels; nicotine and tar levels were first measured in 1967. Before 1967, both demand and supply sides had no information concerning nicotine and tar levels. As information regarding the levels of nicotine and tar had not yet been disclosed, even as late as 1966, it can be assumed that consumers’ knowledge of nicotine and tar levels did not affect their consumption of cigarettes. After 1967, however, it can be inferred that consumers’ behavior was influenced by the new information.

The third information disclosure event occurred on April 20, 1972, when the Japanese Ministry of Finance issued a direction to companies to put a warning label on cigarette packs. Specifically, manufacturers were required to add the label, “Let’s be careful about smoking too much for health reasons.” This warning had to be displayed on the packs of all brands from April 1972.

## 5.5 Data, Data Issues, and Their Solutions

### 5.5.1 Data and Graphs

The time-series sales data for each brand come from the “National Budget” and the “History of the Japanese Cigarette Monopoly”. Fifty-five brands that comprised more than 95 percent of total market share (after 1960) were used. In addition, the data included each brand’s price and respective levels of nicotine and tar. The nicotine and tar-level data were announced officially in the “Asahi Shimbun” and the “Mainichi Shimbun”<sup>3</sup>.

Policy dummies were used to indicate whether disclosure of information had occurred, i.e., they were taken as ‘0’ before an event occurred, and ‘1’ after the event. A time trend was also used. In addition, macroeconomic factors, such as income and population, were taken into consideration. The time transition of nicotine and tar levels per cigarette is presented in Figure 5.1. This graph shows that cigarettes’ nicotine and tar contents decreased after 1967, and that the decrease in nicotine levels was slightly more sudden than that of tar. Figure 5.2 presents the time transition of annual per capita cigarette consumption versus annual consumption per smoker. Cigarette consumption per capita increased until the mid-1970s and then levelled off. Cigarette consumption per smoker<sup>4</sup> has been increasing until the present time. The total intake of nicotine and tar per capita is presented in Figure 5.3. Nicotine consumption exhibited an upward trend until 1967 but declined thereafter. This trend then reversed upwards again until 1972, but shifted to another downtrend thereafter. Tar consumption, on the other hand, increased slowly after 1967 and declined from 1972. The total intake of nicotine and tar per smoker is presented in Figure 5.4. The pattern of nicotine consumption exhibits similar tendencies to that of tar; the trend was upwards until 1963, but then shifted to a downtrend from 1964. However, it is noteworthy that in 1972 nicotine consumption moved in the opposite direction to that of tar consumption.

To help assess the subjective changes in consumer consciousness that occurred with the dissemination of new information, this analysis made use of the number of newspaper articles with headlines containing relevant keywords. As shown in Figure 5.5, the number of articles with titles related to the harmful effects of smoking, or to not smoking, suddenly increased af-

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<sup>3</sup>The “Asahi Shimbun” and the “Mainichi Shimbun” are the main newspapers in Japan.

<sup>4</sup>Calculation details are presented in Wan (2004a).

ter 1964. There were a few more articles with titles including the key word “nicotine” than there were titles including “tar” around 1967, although the number of articles with titles containing the key word “tar” increased from 1972. It seems that these changes in consumer consciousness correspond to the changes in consumption patterns shown in Figure 5.1 and to the changes in the total intake of nicotine and tar shown in Figure 5.4.

## 5.5.2 Data Issues

### Data after 1984 Omitted

New brands are introduced to the market successively. This could result in underestimation of the effect of information disclosure, as newer brands tend to have lower levels of nicotine and tar; thus, data for brands introduced after 1984 were not included in the econometric model<sup>5</sup>. However, the effect of information disclosure was significant, even with this omission, which implies that the effect of information disclosure would have been much greater if the data for newer brands had been included in the estimated model.

### Missing Values

An assumption that the sales of new brands were zero in the period prior to their release, 1950-1984, would have been too strong. In other words, JT was assumed to be capable of supplying any brand at any time and the possibility that a new brand could not be sold at all times was not considered. This corresponds completely with consumer demand for brands before they were introduced, an assumption that is clearly not realistic. Moreover, because price information was lacking, data for new brands for the period prior to their availability were, of necessity, dropped and were considered to be missing values in this analysis. Additionally, a similar problem arose in dealing with the sales volume of a particular brand in the period after its sale had been stopped due to a lack of market demand. The question arose as to whether to use zero or to assume a missing value; thus, it is necessary to discuss the potential biases of the estimators resulting in each case.

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<sup>5</sup>Data from 1985 is not available because JT has not been disclosing the inter-brand cigarette sales since the privatization in 1985.



### 5.5.3 Data Problem Solutions

The first step was to construct two samples, a full sample and a sub-sample. In the full sample, the volume of sales during the period after a brand had been discontinued was chosen as zero, and the price, nicotine, and tar levels of the brand just before sales ceased were used as data for the brand for the period after its discontinuation. In the sub-sample, values for the post-brand period were dropped (688 remained after 150 had been dropped).

The second step was to estimate the econometric model using the full sample. The estimates from the full sample regression may have overestimated the effect of information disclosure because the sales of discontinued brands may not have been identically zero, i.e., some would have continued to be sold in small amounts, if not completely withdrawn from the market. Thus zero consumption of these brands constitutes an extreme case.

The third step was to estimate the model using the sub-sample. The estimation in this case was likely to underestimate the coefficients, because the omitted values tended to be over-represented by the data for the period when a brand was on sale and because the sales of a discontinued brand might, in fact, have been zero, even if it were not withdrawn from the market. Finally, I compared these two types of estimates. The true value of the parameter should fall between the two estimates resulting from the previously detailed regressions.

## 5.6 Model and Estimation

### 5.6.1 Impact on Consumers

#### Modeling the Effect of the 1964 Policy Event

The response of consumers to the 1964 policy event can be considered as represented by the adjustment of total cigarette consumption and inter-brand switching. Ideally, a consumer should restrict her consumption of plain cigarettes, if she only has information regarding plain and filter cigarettes. Therefore, plain cigarette consumption was used to characterize a treatment group, and filter cigarette consumption was used to characterize a control group.

## Modeling the Effect of the 1967 Policy Event

In 1967, the response of consumers to the disclosure of information about nicotine and tar content levels can be thought of as being represented by switches among brands or adjustment of total consumption, following the disclosure of nicotine and tar information. Once consumers became aware that nicotine and tar were bad for their health, demand for the brand with a high nicotine or tar content would have decreased, while demand for the low-nicotine brands characterizing the control group would have increased.

## Modeling the Effect of the 1972 Policy Event

The consumer response to the warning label on cigarette packs, “Let’s be careful about smoking too much for health reasons,” introduced in 1972, can also be thought of as the market’s response to the disclosure of nicotine and tar information in 1967.

## Econometric Model

As in the model of Wan (2002c), consumers’ consumption of cigarettes was based not only on cigarette price, but also on available information concerning the damaging effects of smoking. If one ignores the aspect of addiction, a simple model for cigarette brand demand can be described as follows: demand for brand<sub>it</sub> = f (the attributes of the brand<sub>it</sub>; policy information; and etc.). The attributes of the brand, and policy information, can be used as a proxy for the extent of consumer information about the harmful effects of smoking.

$$\begin{aligned} D_{it} = & \beta_0 + \beta_1 * time + \beta_2 * realprice_{it} + \beta_3 * realincome_t + \beta_4 * after64 \\ & + \beta_5 * plain_i + \beta_6 * after64 * plain_i + \beta_7 * after67 + \beta_8 * tar_{it} \\ & + \beta_9 * after67 * tar_{it} + \beta_{10} * nicotine_{it} + \beta_{11} * after67 \\ & * nicotine_{it} + \beta_{12} * after72 + \beta_{13} * after72 * tar_{it} \\ & + \beta_{14} * after72 * nicotine_{it} + a_i + u_{it}. \end{aligned}$$

There are three assumptions,

$$\text{Assumption 5.1 : } E(u_{it}|x_{itj}, a_i) = 0,$$

$$\text{Assumption 5.2 : } Cov(x_{itj}, a_i) = 0,$$

$$\text{Assumption 5.3 : } Corr(v_{it}, v_{is}) = \sigma_a^2 / (\sigma_a^2 + \sigma_u^2),$$

where,  $t \neq s$ ,  $v_{it} = a_i + u_{it}$ ,  $\sigma_a^2 = Var(a_i)$ ,  $\sigma_u^2 = Var(u_{it})$ ,  $x$  are explanatory variables, and  $j=1, 2, \dots$ , is the number of explanatory variables;  $i= 1, 2, \dots, 55$ ;  $t=1, 2, \dots, 35$ .

The three assumptions presented above are consistent with the characteristics of the sample. It can easily be verified that Assumptions 5.1 and 5.2 are satisfied by the sample used, as the explanatory variables were the attributes of brands and policy information. Furthermore, the likelihood that the error terms were serially correlated was high, as the dataset was a 55-brand time-series spanning 35 years. This is consistent with the third assumption. The following hypotheses were constructed. For the event in 1964, it was expected that  $\beta_6 < 0$ . For the next event, it was expected that  $\beta_9 < 0$  and  $\beta_{11} < 0$ . For the event in 1972, it was expected that  $\beta_{13} < 0$  and  $\beta_{14} < 0$ . A time trend was included in the estimated model to control for the possibility that consumers' preferences might have changed with time. The number of observations, maximum value, minimum value, average, standard error, and so on, for each variable, are given in Tables 5.1 and 5.2. The variables were constructed as follows.

- D: annual demand for each brand, divided by the Japanese population;
- time: a time trend, 1950, 1951, ..., 1984;
- real price: the nominal price of each brand, which was totally controlled by the Japanese government, divided by the consumer price index (CPI);
- real income: Japanese per capita disposable income;
- after64: time dummy: 1 after 1964, and 0 before 1964;
- plain: dummy for plain brands: 1 if the brand was plain, and 0 if the brand was filter-tipped;
- after64\*plain: term for the intersection of after64 and plain;
- after67: time dummy: 1 after 1967, and 0 before 1967;
- tar: the tar content of each brand as disclosed in the newspapers;
- after67\*tar: term for the intersection of after67 and tar;
- nicotine: the nicotine content of each brand as disclosed in the newspapers;
- after67\*nicotine: term for the intersection of after67 and nicotine;
- after72: time dummy: 1 after 1972, and 0 before 1972;
- after72\*tar: term for the intersection of after72 and tar;
- after72\*nicotine: term for the intersection of after72 and nicotine.

## **Multicollinearity**

As high-tar brands always have a high nicotine content, tar content is strongly and positively correlated with nicotine content, as is shown in Figure 5.6. The possibility of multicollinearity arises when nicotine and tar are both included in a regression equation, and thus either nicotine or tar was dropped from the model to control for this potential problem.

## **Nicotine and Tar Measurement Errors Reported by JT**

JT tends to underreport the amounts of nicotine and tar in its cigarettes each year, because this strategy is considered likely to increase the demand for cigarettes. In this type of situation, attenuation bias will become more serious when fixed-effect estimation is used. Thus, random-effect panel estimation was used here to control for the bias caused by the measurement errors induced by misreporting.

## **Random-effect GLS Panel Estimation**

Random-effect GLS panel estimation was used in this analysis, because it facilitated correction for the serial correlation of error terms and the reported nicotine and tar measurement errors under Assumptions 5.1, 5.2, and 5.3. A further important reason for using this method was that nicotine and tar content levels are nearly time invariant.

## **5.6.2 Impact on the Monopolistic Firm**

Figures and difference tests were used to determine the impact of mandatory disclosure on the monopolistic firm. Figures 5.7-5.12 graph JT's behavior both before and after mandatory disclosure regulation was imposed. Difference tests for the nicotine and tar content of discontinued brands, as well as those of new brands, both before and after 1967, were performed to verify whether there were significant differences.

## 5.7 Results

### 5.7.1 Impact on Consumers

The estimates from the models using each of the two samples are summarized in tables 5.3-5.5. Random-effects GLS estimation was desirable from the standpoint of the above-mentioned measurement errors and the serial correlation of the error terms. Only the results of the random-effects GLS estimation are reported.

Table 5.3 presents the results for the full-sample and sub-sample regressions including nicotine. The coefficient on `after64*plain` is significantly negative. This suggests that the sales of plain cigarettes decreased significantly. In addition, the coefficient on `after67*nicotine` is also significantly negative, indicating that the sales of high-nicotine brands decreased significantly, as compared with those of low-nicotine brands, after the introduction of the information disclosure regulations in 1967. Furthermore, the coefficient on `after72*nicotine` is significantly negative. This means that the greater availability of nicotine information decreased the sales of high-nicotine brands after the warning label legislation of 1972. Compared to the estimated coefficients and elasticities of the full-sample regression, those of the sub-sample regression are only slightly smaller. Therefore, the true estimates should fall between these two results.

Table 5.4 presents results of the full-sample and sub-sample regressions including tar. The coefficient on `after64*plain` is significantly negative, which suggests that sales of plain cigarettes decreased significantly. In addition, the coefficient on `after67*tar` is significantly positive, indicating that the greater availability of tar information significantly decreased sales of low-tar brands after the information disclosure regulations were introduced in 1967. The coefficient on `after72*tar` is significantly negative, which implies that the increased tar information decreased sales of high-tar brands following the warning-label legislation of 1972. The estimated coefficients and elasticities from the sub-sample regressions are again only slightly smaller than those from the full-sample regressions. Therefore, the true estimate should lie between estimates derived from the two samples.

Table 5.5 presents further results from the full-sample and the sub-sample regressions. In this instance, the variables for both nicotine and tar content were included in the model. Though there was not a large change in the coefficient on policy information, the elasticity and significance of the coefficient

on after72\*nicotine, the coefficient on after72\*tar, and the coefficient on price changed remarkably. The presence of multicollinearity in these estimates was therefore inferred.

From tables 5.3-5.5, it can be concluded that the demand for plain cigarettes decreased as a result of the legislation in 1964, that the demand for high-nicotine brands decreased due to the policy event of 1967, and that the demand for high-nicotine or tar brands further decreased as a result of the 1972 regulations.

### **5.7.2 Impact on the Monopolistic Firm**

During the period of voluntary disclosure (before 1967), JT did not disclose content information. In contrast, JT disclosed all information regarding nicotine and tar content during the period of mandatory disclosure (after 1967). Figure 5.7 presents the number of brands on sale and the average annual sales of each brand. The number of brands on sale increased continuously, and the rate of increase became greater after the mid-1960s. Furthermore, the annual average sales of each brand decreased continuously. JT supplied more brands after the introduction of mandatory disclosure. Figure 5.8 presents the number of new plain and filter brands introduced each year. Before 1964, three plain brands were introduced, but after 1964 there were no new plain brands. Only two filter brands were introduced before 1964, but after 1964 47 filter brands were introduced. Thus, JT supplied more filter brands and fewer plain brands after the policy event of 1964. Figure 5.9 graphs the time transitions of the numbers of discontinued and new brands. It is clear that remarkably large numbers of new brands were introduced in 1964, 1967, and 1972. No brands were discontinued before 1972, but many were discontinued thereafter. These facts imply that JT introduced many new brands in response to the events of 1964, 1967, and 1972, and discontinued many brands in response to the policy event of 1972. Figure 5.10 presents the average nicotine contents of both discontinued and new brands. It is clear that the average nicotine content of the discontinued brands was higher than that of the new brands, and this implies that JT discontinued many high-nicotine brands and introduced many low-nicotine brands. Figure 5.11 presents the average tar contents of discontinued and new brands. It is clear that the amount of tar in the discontinued brands was higher on average than that of the new brands, and this implies that JT discontinued many high-tar brands and introduced many low-tar brands. Figure 5.12 presents JT's R & D be-

havior. R & D costs versus the ratio of R & D costs to total sales revenue increased continuously, and at an increasing rate, after the mid-1960s. This implies that JT invested in more R & D during the period of mandatory disclosure.

As shown in Table 5.6, after 1967, 20 brands were discontinued, while 39 new ones were introduced; 13 brands were introduced before 1967. The average nicotine and tar content per cigarette of these brands is summarized in Table 5.3. As a result of a difference test, it was determined that the nicotine and tar content of the cigarettes discontinued after 1967 was higher than that of the newer brands. Moreover, it was likewise determined that the nicotine and tar content of brands introduced before 1967 was much higher.

Medical research has verified that low-tar cigarettes are of better quality than high-tar ones, as tar is a cause of cancer; thus, filter cigarettes are of better quality than plain ones, because filters remove some of the tar and other harmful ingredients. In light of previously discussed facts, the characteristics of JT's behavior before and after the mandatory disclosure legislation are clear. In short, JT supplied newer and better quality products, discontinued products of poorer quality, and conducted more R & D in response to the mandatory disclosure regulations.

## 5.8 Conclusion and Remaining Issues

This paper presented a new way to test the effects of information disclosure on consumption, and this methodology was used to test the effects of mandatory information disclosure regulations on Japanese inter-brand cigarette demand and monopolistic firm behavior.

It was found that the demand for plain cigarettes decreased due to regulation in 1964, and that the demand for high-nicotine brands decreased due to the mandatory disclosure pronouncement of 1967; it was also found that the demand for high-nicotine or high-tar brands decreased due to labeling warnings in 1972. These results are consistent with the time transition of average nicotine and tar per cigarette, the time transition of total nicotine intake, and the tar per capita or per smoker. This suggests that the cigarette consumer experienced a shortage of information before the information disclosure events took place, as the mandatory disclosure of information resulted in a decrease in the intake of tar per capita and per smoker. This implies that mandatory disclosure is likely to decrease the incidence of cancer caused

by tar intake and increase consumers' welfare, if we suppose that they always choose their favorite cigarettes.

Compared with the period prior to 1964, JT supplied more filter-tipped brands and ceased production of its new plain brands after the policy event in 1964. It was found that the nicotine and tar content of brands introduced before 1967 was significantly higher than that of new brands introduced after the regulated mandatory disclosure of nicotine and tar information in 1967. It was also found that after 1967 the nicotine and tar content of discontinued brands was significantly higher than that of introduced brands. In summary, JT supplied more and better quality products, discontinued products of poorer quality, and conducted more R & D in response to the mandatory disclosure regulations.

The policy implications of this paper are as follows. Mandatory information disclosure is very important and is as indispensable as many other regulations in Japan, such as the 'Food Safety Proposal', the JAS Law, the Food Sanitation Law, the Product Liability Law, and so on. These regulations are of great significance to the consumer in light of the current lack of information provided to consumers, and they will force monopolistic firms to improve product quality.

In closing, there are two major issues that have not been addressed in this study. The first is that the addictive nature of smoking was not considered in the estimated model. It would be interesting to introduce the effect of information disclosure into the frameworks of Becker et al. (1994) or Wan (2002c). The second issue is that the approach of Yen and Chern (1992) should have been used to estimate information effects. However, when this approach was used, data limitations became a key problem, because the dataset has too many brands, too many missing values, and a very short time-series.



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## 5.10 Figures

## 5.11 Tables

# Chapter 6

## Is Gambling Addictive? Evidence from Pachinko Participation, Quitting, and Re-Initiating

JEL classification: D12, D19, D81; Keywords: addiction, gambling, pachinko

### 6.1 Introduction

Pachinko became popular in Japan during the 1920s<sup>1</sup>. It is still very popular in Japan today, and forms the basis of a large industry. A pachinko parlor (or hall or shop) can be found on nearly every street. Based on the “Basic Survey of Service Industries<sup>2</sup>,” a summary and the estimated added value from pachinko parlors are shown in Table 6.1. From this table, we can infer

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<sup>1</sup>The game is currently divided into two types; one is called “pachinko,” which is a mechanical gambling game, and the other is called “pachinko slot,” or “pachisuro,” which is a digital (i.e., computer style) gambling game that appeared recently, owing to the development of computer technology. The opportunity to gamble constitutes the common feature of the two games, although they differ with respect to the gambling times and the techniques involved.

<sup>2</sup>This survey (in Japanese, Sabisugyou Kihon Chousa), which is performed by the Ministry of Public Management and the Ministry of Economy, Trade and Industry in Japan, was started in 1989 and has been revised every five years. It has been continued to date.

that pachinko is a sizeable service industry. The market volume of pachinko (i.e., sales or revenues of pachinko parlors) was over 28.469 trillion yen (5.6

Because pachinko is so widely played by the Japanese, it is associated with two social issues: pachinko addiction and household bankruptcy, caused by excessive pachinko playing. According to the reports “Survey of Pachinko Addiction”<sup>3</sup> and “Survey of Pachinko and Pachinko-Slot Players”<sup>4</sup>, about 29 percent of players considered themselves pachinko addicts in need medical treatment and about 30 percent of players exceeded their planned budgets and borrowed money. Figure 6.1 shows the relationship between the likelihood of borrowing money and failing to control one’s budget and considering himself or herself a gambling addict. From Figure 6.1, it is very clear that those who thought of themselves as both a pachinko addict and a gambling addict were more likely to borrow money than those who thought of themselves as only a pachinko addict.

From these two direct surveys, it is evident that the social issues related to pachinko playing are very serious. Is pachinko playing really addictive, as found in the aforementioned surveys? Some formal tests are required to answer this question, as respondents might not tell the truth, and real addicts might not consider themselves addicts. If it can be shown empirically that pachinko playing is addictive, then some suitable regulatory polices will be needed.

Furthermore, in the framework of economics, pachinko playing is a very interesting case because it is a type of gambling.<sup>5</sup> In the traditional framework, for example, of expected utility with a risk-averse agent, there is no explanation for gambling. This is because the expected return from gambling is significantly negative, but its market price is positive. This seems to be a conundrum. Another explanation for participation in gambling has been offered in the non-expected utility framework, used by Kahneman and Tversky (1979) and in many other works. Although these approaches have been supported, in the main, by experimental economics, there has been little evidence derived from actual data in support of the non-expected utility

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<sup>3</sup>This survey was performed by the Japan Gaming Labor Union Association in November 2003. Pachinko parlor managers were randomly surveyed and, 4,645 effective answer sheets were obtained in Japan (the response rate was 98.8 percent).

<sup>4</sup>This survey was performed by the Japan Gaming Labor Union Association in December 2003. Pachinko players (including pachinko slot players) were randomly surveyed, and 4,493 effective answer sheets were obtained in Japan (the response rate was 99.7 percent).

<sup>5</sup>Nevertheless, gambling is prohibited (185th article of the Japanese criminal code).



hypothesis.

Friedman and Savage (1948) authored a famous theoretical study on gambling in which the concave-convex-concave utility function of wealth (or income) was proposed as an explanation for gambling, within the framework of expected utility. Although empirical analyses, such as that of Brunk (1981), have been conducted regarding this hypothesis, Bailey and Wonnacott (1980), and Hartley and Farrell (2002) have pointed out a theoretical problem with the Friedman and Savage hypothesis. In order to analyze participation in gambling, Wonnacott (1980) extended the Friedman and Savage utility function to two periods, while Hartley and Farrell (2002) extended it to an infinite horizon. In a dynamic setting, in which the participant considers the long-term, these two papers concluded that the Friedman and Savage hypothesis cannot explain even fair gambling unless some severe conditions are imposed; for example, if the financial markets were to fail. Furthermore, as Hartley and Farrell (2002) mentioned, repeated participation in gambling can be explained more easily by the addiction hypothesis, proposed by Becker and Murphy (1988) than by any other hypothesis.

Other literature has provided support for the addiction hypothesis by analyzing smoking, drinking, coffee consumption, and other data. Moreover, Farrell, Morgenroth, and Walker (1999) tested the addiction hypothesis using time-series data for the public lottery in Britain and found evidence to support the addiction hypothesis. Mobilia (1993) also provided evidence to support the addiction hypothesis using time-series data of horse racetracks in the United States. However, to date there has been no research with regard to testing the addiction hypothesis of gambling with individual data.

Thus, a clarification of the preferences of gambling participants is very important. A consensus has not yet been reached with regard to the utility function that should be used to express participants' preferences. In economic theory and empirical economic analyses to date, it has been argued that both expected utility and non-expected utility are suitable frameworks<sup>6</sup>. If the addiction hypothesis of gambling were to be strongly supported, it would constitute not only an important contribution to the field of economics but also an important contribution to suitable policies for pachinko regulation in the future.

This research analyzes the pattern of pachinko participation, quitting, and re-initiating behavior during and before 2002; it also provides a de-

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<sup>6</sup>See Starmer (2000) for details.

scription of the playing environment and tests the addiction hypotheses of gambling using individual data from the Japanese Pachinko Survey. We obtained strong evidence to support our conclusion that pachinko playing is addictive.

This paper consists of five sections. Section 2 presents the theoretical framework of myopic addiction. Section 3 presents the data and estimation technique. Section 4 reports the estimation results. Section 5 concludes and discusses policy implications.

## 6.2 Theoretical Frameworks

A representative consumer is assumed to consume two goods: one is pachinko playing ( $C_t$ ), and the other is the composite commodity ( $Y_t$ ). The consumer is assumed to fail to consider the impact of current consumption on future utility and future consumption. Following Fenn et al. (2001), the myopic consumer faces a one-period problem:

$$\begin{aligned} \max U(C_t, C_{t-1}, Y_t, e_t). \\ \text{s.t. } Y_t + P_t C_t = A_t, \end{aligned} \tag{6.1}$$

where  $P_t$  is the price of pachinko playing, and  $A_t$  is period t income. The solution is

$$C_t = \eta + \gamma S_{t-1} + \gamma_1 P_t + \gamma_2 e_t, \tag{6.2}$$

where  $S_{t-1}$  is the stock of pachinko playing at time t. We make the following hypotheses:  $H_0$ :  $\gamma > 0$ ; and  $H_1$ :  $H_0$  is not true.

Under the null hypothesis, the consumer is considered addicted to pachinko playing. We will test this hypothesis using four pieces of information, namely pachinko participating, quitting, re-initiating, and the stock of pachinko playing.

## 6.3 The Data and Estimation Methods

### 6.3.1 Data Source

The data used in this paper are individual data taken from the Japanese Pachinko Survey 2003<sup>7</sup>, performed by the Ace Research Institute. The Institute has been carrying out the Japanese Pachinko Survey annually since 1995. The candidates chosen for investigation were over eighteen years of age at the time of the survey and were randomly selected from the Japanese population. The posting (questionnaire) method is used in this survey, which was conducted in August and September 2002. The number of effective replies (respondents) was 1,508 (863 samples were for participants and players who had quit and non-participants, 645 samples were players who had quit)<sup>8</sup>. The investigation examined current and past participation behavior, the will to quit or re-initiate pachinko playing and pachinko-slot playing, as well as other characteristics of the participants, including occupation, sex, age, marital status, and income.

### 6.3.2 Information Used for the Empirical Test and Descriptive Statistics

The questions that are described in detail in Appendix 1 provided the data that were used for econometric analysis. The information regarding participation in the past year, the will to quit now or in the future, the quitter's will to re-initiate after quitting, the duration of non re-initiation after quitting, the status of new players, and age were used to examine the addiction hypothesis. The descriptive statistics for each variable are presented in Table 6.2. The way in which each variable was constructed is described in Appendix 2.

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<sup>7</sup>These data are available in the Social Science Japan Data Archive, Institute of Social Science, University of Tokyo. Anybody can access them with an application.

<sup>8</sup>Strictly speaking, there are two surveys. The survey population of the first survey is Japanese ages eighteen and over, while the population of the second survey is those who have quit playing pachinko (including pachinko slot) for more than one year before the survey date.

### **6.3.3 Estimation Technique**

#### **Does Participation Increase with Experience?**

Interval data for participation frequency over the previous year were available. According to Caudill (1992), ordinary least squares (OLS) estimation using midpoints will not result in a consistent estimator when the dependent variable consists of interval data; therefore, an interval regression based on maximum-likelihood estimation is suitable in this context. With this result in mind, I present and consider an interval regression model. The marginal effect of estimation will be reported.

The dependent variable is participation frequency, or money spent on pachinko playing, or hours of playing pachinko over the previous year. The independent variables are the attributes of the respondents, age, and a dummy variable for new players with less than one year experience. Under the null hypothesis, the coefficient of age should be significantly positive, and that of new player should be significantly negative.

#### **Does the Will to Quit Playing in the Future Increase with Experience?**

A probit model is suitable in this instance, and the marginal effect of estimation will be reported. The dependent variable is a dummy variable, which is equal to 1 for the respondent who will quit playing pachinko and 0 for the respondent who will not. The independent variables are participation frequency over the past year and the attributes of the respondents. Under the null hypothesis, the coefficient of the participation frequency should be significantly negative.

#### **Did the Will to Re-initiate After Quitting Increase with the Extent of Experience Just Before Quitting?**

Count data for the will to re-initiate after quitting are available, and thus an ordered probit regression model is used. The dependent variable is the will to re-initiate after quitting in the past. The independent variables include experience (participation frequency, payments, and hours) in the year just before quitting. Under the null hypothesis, the coefficient of experience should be significantly positive.

## Did the Duration of No Re-initiation After Quitting Decrease with Experience in the Year Immediately Before Quitting in the Past?

The data for duration of no re-initiation after quitting are available, and OLS regression with robust standard errors is used<sup>9</sup>. The marginal effect of estimation is also reported. The dependent variable is the duration of no re-initiation after quitting. The independent variables include payments for pachinko playing in the year just before quitting. Under the null hypothesis, the coefficient of the payments should be significantly negative.

### 6.4 Estimation Results

In Table 6.3, the coefficients for ages 18-19 and 30s are not significant, but those for ages 40s, 50s, and over-60s are significantly positive. In the first column, the elasticity for ages 40s, 50s, and over-60s is 0.093, 0.135, and 0.045, respectively. In the second column, the elasticity is 0.093, 0.135, and 0.045, respectively. In the third column, the elasticity is 0.080, 0.151, and 0.030, respectively. If age is a good proxy of pachinko-playing experience, this result is consistent with the addiction hypothesis. However, age might represent only the cohort effect, and thus we cannot say that the significantly positive effect of age strongly supports the addiction hypothesis. We can say that at least this result does not contradict the addiction hypothesis. The dummy for a new player, pachinko-new, is not significant, possibly because of too few samples (only twenty respondents).

The coefficient of yearly-times in Table 6.4 is significantly negative. The elasticity of the yearly-times in the first column and the second column is  $-0.352$  and  $-0.344$ , respectively. This result means that the frequency of participation over the previous year significantly decreases the will to quit the activity in the future, and the elasticity is quite large. This is strong evidence in support of the addiction hypothesis.

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<sup>9</sup>The data of duration are all right censored, because the duration of non re-initiation was still continuing at the survey date. Thus, there is measurement error in the dependent variable (duration). This (exogenous) measurement error will not bias the estimated coefficient but will overestimate the standard error of coefficient when using OLS. Because the mean of the measurement error is just equal to the mean of observed duration, the estimated elasticity is overestimated by a factor 2. Thus, to obtain the real elasticity, suitable adjustment is necessary. The estimated elasticity should be multiplied by 0.5 to return to the real elasticity.

The estimation in Table 6.5 is for the persons who have quit participation for over one year. The coefficients yearly-past-times, yearly-past-manyen and yearly-past-hours are significantly positive<sup>10</sup>. This is further strong evidence in support of the addiction hypothesis.

The estimation in Table 6.6 is for those who have quit participation over one year ago. The coefficient of manyen-before-quitting is significantly negative. Because real addictive behavior is very difficult to quit, and very easy to re-initiate after quitting, this empirical result is very strong evidence in support of the addiction hypothesis. We have calculated the elasticity. The elasticity<sup>11</sup> in the first, second, and third columns is -0.010, -0.009, and -0.016, respectively.

## 6.5 Conclusion and Policy Implication

Using a unique data set taken from the Japanese Pachinko Survey 2003, this study analyzed the pachinko-participation situation in Japan and tested the addiction hypothesis of gambling. The findings are as follows:

There are large numbers of pachinko participants, and the market volume for the Japanese pachinko industry exceeded 28 trillion yen in 1999; the added value was about 0.86 percent of GDP. According to the results regarding participation, the will to quit the activity in the future, the will to re-initiate after quitting, and the duration of no-re-initiation after quitting, the addiction hypothesis of gambling is strongly supported. Pachinko-playing experience significantly decreases the will to quit in the future, increases the will to re-initiate after quitting, and decreases the duration of no re-initiation after quitting.

Therefore, recent and past behavioral patterns of participation in pachinko-playing in Japan are clearly consistent with the characteristics of gambling and addictive behavior. This is a striking result in the context of the empirical analysis of gambling theory. We should expect many more theoretical

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<sup>10</sup>The elasticity of yearly-past-times is  $-0.107$  (outcome (1)),  $0.086$  (outcome(2)),  $0.246$  (outcome(3)), and  $0.462$  (outcome(4)), respectively; the elasticity of yearly-past-manyen is  $-0.049$  (outcome (1)),  $0.040$  (outcome(2)),  $0.112$  (outcome(3)), and  $0.208$  (outcome(4)), respectively; the elasticity of yearly-past-hours is  $-0.048$  (outcome (1)),  $0.038$  (outcome(2)),  $0.108$  (outcome(3)), and  $0.203$  (outcome(4)), respectively.

<sup>11</sup>We have made the adjustment noted in Footnote 10. The estimated elasticity has been multiplied by 0.5.

and empirical analyses of gambling to be conducted in the future, as existing theories have not yet been able to explain gambling.

According to the reports “Survey of Pachinko Addiction” and “Survey of Pachinko and Pachinko-Slot Players”, pachinko playing is related to two social issues: pachinko addiction and the probability of household bankruptcy. It is also reported that 29.3 percent of respondents who think of themselves as a pachinko addict think that they need medical treatment for their addiction. Thus, some suitable regulatory policies are necessary because of its negative externality. For example, the government could set an upper playing bound for heavy pachinko players, or make the pachinko parlors monitor heavy players and control their participation or provide medical treatment. Furthermore, in the context of future discussions regarding the regulations and laws related to the pachinko industry, it is expected that the evidence presented here—that pachinko behavior is consistent with gambling and addiction behavior—will become an important material reference for policy makers.

The evidence in this study is also very helpful in reconsidering the assumption of risk-aversion, which is one of the most standard in modern economics, and in understanding the bubble (fundamentals are a minus expected return, but a positive market price) as well. We expect there to be more linkages between the bubble and gambling in the future.

The player’s “rationality” is not tested here. To test it, a tax or price shock is needed. This issue is left for future research.

## Appendix 1: Data

Main questions used for this paper

Question 1 (for all respondents) Please circle your frequency of participation over the past year for the following leisure activities.

1. 5-7 times per week; 2. 2-4 times per week; 3. About once per week; 4. 2-3 times per month; 5. About once per month; 6. about once every 2-3 months; 7. about once every 4-5 months; 8. About once every six months; 9. About once per year; 10. Experienced once but did not play during the past year; 11. Have no experience; 12. Do not know.

Question 2 (For the respondents who had played pachinko at least once during the previous year) On average, what was your expenditure per pachinko game?

--\_yen.

Question 3 How many hours did you play per pachinko game?

1. Less than 30 minutes; 2. 30 minutes-one hour; 3. 1-2 hours; 4. 2-3 hours; 5. 3-4 hours; 6. 4-5 hours; 7. 5-8 hours; 8. over 8 hours; 9. I do not know.

Question 17 (For the respondents who quit playing pachinko) When did you play your last pachinko game?

1. 2002; 2. 2001; 3. 2000; 4.1999; 5. 1998; 6. 1997; 7. 1996; 8. 1995; 9. 1994; 10. 1993; 11. 1992; 12. Before 1991; 13. I do not know.

Question 18 (For the respondents who had quit playing pachinko) Please circle the frequency of your participation over the year before your last pachinko game.

1. 5-7 times per week; 2. 2-4 times per week; 3. about once per week; 4. 2-3 times per month; 5. About once per month; 6. About once per 2-3 months; 7. About once per 4-5 months; 8. About once per six months; 9. About once yearly; 10. I do not know.

Question 63. Compared to past year, what change will occur in your pachinko participation frequency in the future? Please circle only one choice.

1. Will increase frequency; 2. No change; 3. Will decrease; 4. Will quit playing; 5. Will re-initiate playing; 6. Will not play, like before; 7. I do not know.

## Appendix 2

Construction of the variables

yearly\_times\_1: frequency of pachinko participation (times per year, left point of the answer interval)

yearly\_times\_2: frequency of pachinko participation (times per year, right point of the answer interval)

yearly\_times: average of yearly\_times\_1 and yearly\_times\_2

yearly\_manyen\_1: payments for pachinko participation (10,000 yen per year, left point of the answer interval)



yearly\_manyen\_2: payments for pachinko participation (10,000 yen per year, right point of the answer interval)  
 yearly\_manyen: average of yearly\_manyen\_1 and yearly\_manyen\_2  
 yearly\_hours\_average\_1: hours for pachinko participation (hours per year, left point of the answer interval)  
 yearly\_hours\_average\_2: hours for pachinko participation (hours per year, right point of the answer interval)  
 yearly\_hours: average of yearly\_hours\_average\_1 and yearly\_hours\_average\_2  
 pachinko\_new: 1 for a respondent with less than one year's experience with pachinko, 0 for others  
 female: 1 for a female respondent, 0 for male  
 age 18-19? 1 for a respondent who was 18 or 19, 0 for others  
 age 20s? 1 for a respondent who was 20 or older but less than 30, 0 for others  
 age 30s? 1 for a respondent who was 30 or older but less than 40, 0 for others  
 age 40s? 1 for a respondent who was 40 or older but less than 50, 0 for others  
 age 50s? 1 for a respondent who was 50 or older but less than 60, 0 for others  
 age 60s\_over? 1 for a respondent who was 60 or older, 0 for others  
 salaried\_worker: 1 for a respondent who was a salaried worker, 0 for others  
 self\_employed? 1 for a self-employed respondent, 0 for others  
 part\_time: 1 for a part time worker respondent, 0 for others  
 student: 1 for a respondent who was a student, 0 for others  
 housewife? 1 for a respondent who was a full-time housewife, 0 for others  
 public\_clerk? 1 for a respondent who was a civil servant or a clerk in an institution, 0 for others  
 no\_job? 1 for a respondent who had no job, 0 for others  
 income\_under\_2million? 1 for a respondent whose yearly income was below 2 million yen, 0 for others  
 income\_2-4million? 1 for a respondent whose yearly income was over 2 but below 4 million yen, 0 for others  
 income\_4-6million? 1 for a respondent whose yearly income was over 4 but below 6 million yen, 0 for others  
 income\_6-8million? 1 for a respondent whose yearly income was over 6 but below 8 million yen, 0 for others

income\_8-10million? 1 for a respondent whose yearly income was over 8 but below 10 million yen, 0 for others

income\_10-15million? 1 for a respondent whose yearly income was over 10 but below 15 million yen, 0 for others

income\_over\_15million? 1 for a respondent whose yearly income was over 15 million yen, 0 for others

per month\_allowance\_manyen: per month allowance (10,000 yen per month)  
quit will: 1 for a respondent who will quit pachinko participation in the future, 0 for others

quit\_period: (for respondents who had quit playing) the duration since quitting pachinko participation (years)

manyen\_before\_quit: (for respondents who had quit playing) payments for pachinko participation over the year just before quitting playing (10,000 yen per year)

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## 6.8 Figures

## 6.9 Tables

# Chapter 7

## Are Gambling and Smoking Complementary? Direct Tests from Japanese Individual Data

JEL classification: D12, E21, E29; Keywords: pachinko gambling, smoking, complementary

### 7.1 Introduction

Many studies have analyzed smoking and, subsequently, regulations have been advised with respect to smoking because of its negative externality (i.e., it is a health hazard). Moreover, other studies have analyzed gambling in Japan and found that pachinko gambling causes an addiction to the game, which often leads to household bankruptcy (Wan 2004). Thus, from the viewpoint of social welfare improvement, suitable regulation policies should be considered. Research linking smoking and gambling behaviors would help to provide policy makers with important information. The lack of such research, linking smoking and gambling, has led us to our current study.

Smoking is a health hazard, but this knowledge does not influence many smokers to quit this seemingly irrational behavior. However, many studies (e.g., Becker, et al. 1994 and Wan 2003) have proved that smoking constitutes a rational addiction behavior. Conversely, gambling has a negative expected return with a positive market price, which begs the question, why

do gamblers continue to make bets? Gambling, therefore, also seems to be an irrational behavior. However, certain studies using time-series data (e.g., Mobilia 1993 and Walker 1999) have found evidence to show that gambling is a rational addictive behavior. Wan (2004)<sup>1</sup>, using individual Japanese data, also provides strong evidence that pachinko gambling is addictive.

In economic theory, there have been few works that have analyzed two addictive goods. Dockner and Feichtinger (1993) have demonstrated that there is cyclical consumption path in a continuous time framework when the consumer consumes two addictive goods. Recently, Bask and Melkersson (2004) presented a testable model (discrete time), then performed a test for drinking and smoking using Swedish time-series data, and found that alcohol and cigarettes are complements. Other studies have analyzed two addictive goods using individual data, without the addiction framework; for example, Decker and Schwartz (2000) found that alcohol and smoking are complements.

Because smoking is a health hazard, and gambling causes household bankruptcy, regulation policy may be necessary to compensate for their negative externalities. If research can show that these two goods are complementary behaviors, a regulation policy that might be more effective could be designed. Therefore, we tested whether smoking and pachinko gambling are complements by using a unique individual data set, and we found that smoking is complementary to gambling and that gambling is also complementary to smoking.

This paper consists of five sections. Section 2 presents the theoretical framework for two additive goods in discrete time. Section 3 presents the data and estimation method. Section 4 reports the estimation results. Section 5 concludes and discusses policy implications.

## 7.2 Theoretical Frameworks

A representative consumer is assumed to consume three goods, the first one is cigarette smoking  $C_t$ , the second is pachinko gambling  $A_t$ , and the other is the composite commodity  $Y_t$ . The consumer is assumed to consider the impact of current consumption on future utility and future consumption. Following Bask and Melkersson (2004), the rational consumer faces the following

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<sup>1</sup>Wan's 2004 study is the first to research gambling addiction using individual Japanese data.



problem:

$$\max_{a_t, c_t, y_t} \sum_{t=1}^{\infty} (1 + \delta)^{-t} U(a_t, c_t, G_t, H_t, y_t). \quad (7.1)$$

$$s.t. \sum_{t=1}^{\infty} (1 + r)^{-t} (y_t + p_{at}a_t + p_{ct}c_t) = W \quad (7.2)$$

where  $p_{ct}$  is the real price of cigarettes and  $p_{at}$  is the real price of pachinko playing;  $G_t$  and  $H_t$  are the respective habit stocks, which measure the degree of addiction.  $r$  is the interest rate and the  $W$  is the present value of wealth.  $\delta$  is the factor of time preference, assumed be positive and equal to  $r$ . The solution<sup>2</sup> is

$$\begin{aligned} a_t = \beta_{10} &+ (1 + r)\beta_{11}a_{t-1} + \beta_{11}a_{t+1} + \beta_{12}c_{t-1} \\ &+ \beta_{13}c_t + \beta_{14}c_{t+1} + \beta_{15}p_{at}, \end{aligned} \quad (7.3)$$

$$\begin{aligned} c_t = \beta_{20} &+ (1 + r)\beta_{21}c_{t-1} + \beta_{21}c_{t+1} + \beta_{22}a_{t-1} \\ &+ \beta_{23}a_t + \beta_{24}a_{t+1} + \beta_{25}p_{ct}. \end{aligned} \quad (7.4)$$

According to these two demand equations, we can predict the signs of the parameters. If cigarette smoking and pachinko are independent,  $\beta_{12}$ ,  $\beta_{13}$ ,  $\beta_{14}$ ,  $\beta_{22}$ ,  $\beta_{23}$ ,  $\beta_{24}$  must be zero. If cigarette smoking and pachinko are complements,  $\beta_{13} > 0$  and  $\beta_{23} > 0$ , but the signs of  $\beta_{12}$ ,  $\beta_{14}$ ,  $\beta_{22}$ ,  $\beta_{24}$  are undecidable. If cigarette smoking and pachinko are substitutes, there must be  $\beta_{13} < 0$  and  $\beta_{23} < 0$ , but the signs of  $\beta_{12}$ ,  $\beta_{14}$ ,  $\beta_{22}$ ,  $\beta_{24}$  are also undecidable. Thus, to test whether cigarette smoking and pachinko are complements or substitutes, the useful parameters are only  $\beta_{13}$  and  $\beta_{23}$ . We will perform two direct tests for these two useful parameters by using a unique individual data set.

## 7.3 The Data and Estimation Technique

### 7.3.1 Data Source

Characteristic 1 is that this data set is opened in the Social Science Japan Data Archive, Institute of Social Science, University of Tokyo. Everyone can access this data with application. Characteristic 2 is that there is detailed

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<sup>2</sup>See Bask and Melkersson (2004) for details.

information about pachinko participation, smoking, shops that ban smoking, smoking when playing, etc. that are summarized in tables 7.1-7.5.

The data used in this paper are individual data taken from the Japanese Pachinko Survey 2003, performed by the Ace Research Institute. The Institute has been carrying out the Japanese Pachinko Survey annually since 1995. The candidates chosen for investigation are randomly selected from the Japanese population, aged 18 and over at the time of the survey. The posting (questionnaire) method was used in this survey, which was conducted in August and September 2002. The number of effective replies (respondents) was 1508.

### **7.3.2 Information used for Empirical Tests**

The data used for the hypothesis test came from the “Japanese Pachinko Survey 2003” that are described in detail in Appendix 1 of Chapter 6 (Wan’s 2004 doctoral dissertation). The information about pachinko playing in the past year, the habit of smoking, the status of smoking when playing pachinko, the desire to play pachinko in a smoke-free facility, etc. are used to identify the hypothesis.

### **7.3.3 Methods**

To show whether the participation is positively correlated with the habit of smoking, two cross tables (tables 7.1 and 7.2) are used to clarify it. We can see the correlations easily by the two tables. To show whether an increase in smoking is conditional upon playing pachinko, we also used one table (table 7.3) to clarify it.

To show whether the desire to play pachinko in a smoke-free facility decreases because of the lack of opportunity to smoke, we used one table (table 7.4) to show the desire and used a cross table (table 7.5) to show their relationship. Then, we performed a three ordered probit estimation to test the hypothesis.

## **7.4 Empirical Results**

Analyzing tables 7.1 and 7.2, it is clear that the participation in pachinko and pachinko-slot is positively correlated. But we cannot know the causality;

in other words, does pachinko playing increase smoking, or does smoking increase pachinko playing?

Table 7.3 analyzes the direct question, put to pachinko players, “What is your smoking status when you are playing pachinko?”, which constitutes a just correspondent to the demand equation (7.4)  $E(c_t|a_t)$ . Respondents were asked to circle one of four replies: (1) “I smoke more, as compared to other times”; (2) “I smoke infrequently, generally, but smoke when playing”; (3) “I never smoke”; and (4) “I do not know.” The percentage of respondents circling the first choice was 40.43, and 7.01 percent of respondents circled the second reply. These results provide strong evidence that pachinko playing increases smoking, and imply that smoking is complementary to gambling.

Table 7.4 analyzes the direct question put to pachinko players, “Would you go to a pachinko facility that bans smoking?” This question constitutes a just correspondent to the demand equation (7.3)  $E(a_t|c_t)$ . Respondents were asked to circle one of five replies: (1) “I would love to go to a smoke-free pachinko facility”; (2) “I might go to such a facility”; (3) “I would not want to go to such a facility”; (4) “I do not want to go to such a facility at all”; and (5) “I do not know.” The percentage of respondents per each answer is, respectively: 20.75, 27.22, 22.64, 24.8, and 4.58. Table 7.5 is a cross table that indicates the questions in tables 7.3 and 7.4. Clearly, the respondents who circle the first answer in table 7.3 are likely to circle the fourth answer in table 7.4, while the respondents who circle the third answer in table 7.3 are likely to circle the first answer in table 7.4. These results provide strong evidence that the desire to play pachinko in a smoke-free facility decreased because of the lack of an opportunity to smoke, and imply that pachinko is complementary to smoking.

We used information in tables 7.3 and 7.4 to perform three ordered probit estimations. The dependent variable was equal to five for the respondents who circled the first answer, four for the second answer, three for the third answer, two for the fourth answer, and one for the fifth answer in table 7.4. We also made two dummies to catch the information in table 7.3. Smoking-much-pachinko is equal to one for the respondents who circled the first answer in table 7.3, zero for the other. Smoking-pachinko is equal to one for the respondents who circled the second answer in table 7.3, zero for the other. The coefficients of smoking-pachinko and smoking-much-pachinko are all significantly negative. Furthermore, the absolute value of the coefficient of smoking-much-pachinko is significantly larger than that of smoking-pachinko. These results strongly support the idea that the desire to play pachinko in

a smoke-free facility decreased, because of the lack of opportunity to smoke, and imply that pachinko is complementary to smoking.

## 7.5 Conclusion and Policy Implications

We have used a unique individual data set to clarify the relation between pachinko gambling and smoking. We have demonstrated not only their positive correlation, but also their causality. Pachinko gambling increases smoking; thus, smoking is complementary to gambling. On the other hand, the desire to play pachinko in a smoke-free facility decreased, owing to the lack of opportunity to smoke; thus, pachinko is also complementary to smoking.

Because smoking and pachinko gambling have strong negative externalities (e.g., smoking is a health hazard and gambling often causes household bankruptcy in Japan) a number of regulation policies (such as a public smoking ban) are needed. Moreover, because of the complementary nature of the two behaviors, the effect of regulation would be two-fold.

Despite our initial research, the field of modern standard economics does not provide answers to behavioral questions such as, “Why do gamblers wager to the point of personal bankruptcy?”, “Why does a bubble always occur in the price of stock and land?” and “Do participants in gambling or in the stock market have a stable preference?” Perhaps gamblers consume two addictive goods, as we have shown in our study. A gambler’s preference to wager may be influenced by other activities, as is smoking. Thus, it is helpful to reconsider participants’ attitudes to risk (uncertainty in gain). In this study, the complementarity of two addictive goods have been clarified, but their addictiveness and stability have not been tested. For example, when  $\beta_{13}$  and  $\beta_{23}$  are sufficiently large, the system equations (7.3) and (7.4) may be unstable. These issues remain to be investigated by future research.

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## 7.7 Tables

# Chapter 8

## Tax Revenue in China and the Incentive to Declare Taxes: The Lottery Purchase Receipt Experiment

JEL classification: H26, D81, D82, C23; Keywords: information asymmetry, operating tax, receipt with lottery, quasi-linear preference, random growth model

### 8.1 Introduction

#### 8.1.1 The Light and Shadow of China's Economy

China's economy shifted to a market economy in 1978 to include the rural contract work system and private companies. Stock markets and special economic zones were founded in the 1980s. In 1994, decentralization separated local and central government, including the taxation system. As shown in Fig. 8.1, after the 1978 shift to a market economy, high growth was realized for more than 20 years. In 2003, China experienced 8% economic growth, and it is expected to achieve over 9% growth in 2004. However, as shown in Figs. 8.2 and 8.3, the budget deficit has become a serious concern and total revenues are decreasing. Moreover, Fig. 8.4 shows the transition of Gini's coefficient, which measures the degree of economic inequality in China.



Clearly, the degree of economic inequality in China is growing. To sustain future economic growth, these two significant issues must be resolved. The implementation of an efficient and fair tax collection system might serve as an effective and reasonable means toward solving China's economic problems; however, at present the country lacks such a tax collection system. Economists have warned of the seriousness of the deficit and inequality issues in China. In February 2004, Shiller (2004)<sup>1</sup> provided six pieces of advice regarding the Chinese economy, and his first recommendation was the creation of an effective taxation system. Similarly, Krugman (2004)<sup>2</sup> noted that "since there is no tax collection system anyway, a possibility that the China government itself will go bankrupt is not zero, either."

### 8.1.2 Issues in Taxation

Even if the government understands the importance of tax collection, if the technical and intellectual ability to create a tax collection system is lacking, the effort will fail. To collect an operating tax (similar to a consumption tax, i.e., about five percent of total sales), income tax, and wealth tax the government needs to obtain private and corporate financial records of transactions, income, and wealth. However, unless the government is willing to pay the significant cost of monitoring the collection process, such information will not materialize. Owing to the asymmetry of information between government and taxpayer, individuals might be tempted to underreport the amount of taxes due. For example, there is the issue of 'kuroyon' in Japan, which refers to the fact that the rates of income recorded for salaried workers, farmers, the self-employed, and politicians are about 90, 60, 40, and 10 percent, respectively. The taxation issue is often a point of contention in Japan and it has been studied for many years. In relation to the 'kuroyon issue', it has been hotly debated in Japan whether a corporate enterprise tax system based on sales, salary, etc., and a taxpayer numbering system should be introduced; however, this argument does not progress easily. When building a tax collection system, a government must make taxpayers cooperate in providing accurate financial information and must design and provide an incentive mechanism that can mitigate informational asymmetry.

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<sup>1</sup>See Shiller (2004) for details.

<sup>2</sup>See Krugman (2004) for details.

### 8.1.3 Tax Evasion in China

For many years mainland China has been wrestling with the issue of capturing a fair tax base. The government first issued a guideline requiring a receipt with lottery transactions<sup>3</sup> (You Jiang Fa Piao, in Chinese) as a means of organizing tax collection. The first experiments with the lottery receipt procedure were held in certain areas on March 4, 1989<sup>4</sup>. Discussion and preparation took ten years prior to the launch of the experiment. On January 1, 1998, the new receipt system came into effect in Haikou City, Hainan Province, which is one of the most open cities in China. The central government evaluated the system's performance and has since increased the trial area incrementally across the nation. According to my May 2003 research using the search engine Google.com, by the end of 2002 there were over 80 big-city-level local tax bureaus countrywide (out of approximately 662) where the experiment is underway. In other words, 12 percent of local tax bureaus are conducting the lottery receipt experiment<sup>5</sup> (see Table 8.1).

Accompanying the lottery receipt experiment, the "Act of China Taxation" was revised, and since May 1, 2001, the "New Act of China Taxation" has been enacted. The detailed enforcement rules for the new act came into effect on October 15, 2002. A new 23rd article has since been added to the new act, which provides that "the equipment which prevents tax evasion should be actively repaired." Specifically, this "equipment which prevents tax evasion" is a patented machine that issues a receipt with every lottery transaction<sup>6</sup>.

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<sup>3</sup>According to "The Act of China Taxation," receipt is defined as a certificate of the monetary transaction, is the primary proof for financial accounting and a tax audit, and is managed with printing, issue, and storage by the taxation bureau. The system of requiring a receipt with lottery transactions appeared in Taiwan in the 1960s, in order to improve tax collection efficiency; Taiwan still uses this system today.

<sup>4</sup>See Note of Mainland China Government (1989) for details.

<sup>5</sup>By the end of 2002, only Beijing and Shanghai had been experimental areas at the provincial or state level, according to data from the China Taxation Bureau. Information regarding the experiments in other areas has not been reported yet as formal statistical data. The figure in Table 8.1 was obtained from the news media. Because these are not government statistics, caution is required when interpreting the information. Therefore, this table approximates the state of the experiments throughout country.

<sup>6</sup>The inventor of the lottery receipt machine is Dai Haiping. He applied for a patent on April 28, 1998, and the China Patent Bureau authenticated the patent on February 21, 2001. This machine can issue the receipt with a special number that is used for a random drawing. The value written on the receipt is reported to the consumer, the firm, and

The experiments were conducted in depth in three of China's largest cities: Beijing, Shanghai, and Tianjin. In Beijing, one district (out of 18) has been conducting the experiment since January 1, 2001; seven districts since August 1, 2002; and the remaining 10 districts have been issuing lottery receipts since October 1, 2002. At first, mainly service industries, such as food service businesses issued receipts with lottery transactions. However, in Shanghai, the experiment began in October 1, 2002, and since January 1, 2003, it has grown to include other service industries such as beauty salons and real estate agencies. In Tianjin, the experiment began on January 1, 2004. Today, the scope of areas conducting the lottery receipt experiment has expanded to many areas.

In this paper, we first analyze theoretically whether the new taxation system in China is well run, then we empirically examine the effect of the new system on tax collection using the "natural experiment" method based on panel data consisting of experimental and non-experimental areas. We found that the new system will work well, even if the consumer has quasi-linear preference and expected utility. In addition, we found that the lottery receipt experiment has caused operating tax revenues to increase significantly.

The structure of this paper is as follows: Section 2 performs a theoretical consideration. Section 3 describes the data, the model, and the method of econometric estimation. Section 4 shows the results, and Section 5 discusses the policy implications and concludes.

## 8.2 Theoretical Frameworks

### 8.2.1 Previous Research

Morgan (2000) presented a mechanism for financing public goods by means of a taxable lottery for consumers with quasi-linear preferences. Morgan's mechanism proved to be more efficient than a voluntary taxpayer system in regard to raising funds for welfare improvement. Morgan and Sefton (2000) further confirmed this theory. Prior to these studies, Friedman and Savage (1948) and Kahneman and Tversky (1979) analyzed lottery purchases; however they did not consider the issue of producing a receipt for lottery transactions as a way to track taxable income.

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the tax bureau simultaneously. The consumer can use the lottery receipt and the special number to investigate the status of the prize by telephone or via the Internet.

## 8.2.2 The Mechanism of Tax Declaration by Lottery Receipt in China

### Issues

In lottery transactions, there are three types of agent: the firm, the consumer, and the government. It is assumed that there are infinite homogeneous firms, and that these firms seek profit maximization within a competitive market. It is also assumed that there is a sufficiently large and homogeneous body of consumers. When a consumer buys a product from a firm, the information on the purchased quantity “V” is shared with the company. The government cannot know about this sale unless it applies a sufficiently large monitoring cost. Although social public welfare will increase if all consumers pay their taxes voluntarily, the consumer has an incentive not to pay taxes because the government cannot supervise the trading volume between the consumer and the firm. It is assumed that the government collects, to the highest extent, sales tax “T” according to the purchased amount “V,” but that it cannot perform proper accounting unless it has correct information regarding the correct amount of “V.” However, the cost of monitoring “V” is larger than the information value of “V” and the tax revenues “T.” Therefore, the government will not act as the monitor of “V” and cannot fully collect the tax “T.”

### Purchase of Lottery Tickets

It is assumed that the government collects taxes on lottery transactions by issuing a receipt with purchase. We analyzed consumers’ purchase of lottery tickets using Morgan’s framework (2000)<sup>7</sup>. In this framework, the government sells fixed-prize raffle tickets (the prize amount is “R”) and informs each consumer of “R” in advance. Consumer  $i$  has wealth  $w_i$  and quasi-linear preference. There are  $N$  consumers in this economy. Consumer  $i$  optimally chooses the amount to purchase  $x_i \in [0, w_i]$ , conditional on the fact that the purchases of other consumers are given. The probability of winning the prize is set to  $x_i/x(N)$  ( $x(N) = x_1 + \dots + x_N$ ). The net revenues to the government for offering pure public goods is  $G=x(N)-R$ . The sales  $x(N)$  of

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<sup>7</sup>The author also analyzed the purchase of lottery in the framework of Kahneman and Tversky (1979) and Guiggin (1991) and found the second order condition for the optimal lottery for government. See Wan (2004) for details.

the lottery are assumed to be large enough to cover the prize  $R$ . The problem of lottery purchase for consumer  $i$  can be set as the following expected utility maximization:

$$EU_i = w_i - x_i + [x_i/x(N)]R + h_i[x(N) - R], \quad (8.1)$$

where  $h_i$  is consumer  $i$ 's utility from pure public goods. The first order condition with respect to  $x_i$  is

$$[x_i/((x(N))^2)]R - 1 + h'_i[x(N) - R] \leq 0. \quad (8.2)$$

In equilibrium,  $N'$  consumers will purchase the amount  $(x_i^*, \dots, x_{N'}^*)$  of lottery tickets, respectively. If the first order conditions of  $N'$  consumers are added, we get

$$\sum_{i=1}^{N'} h'_i[x^*(N') - R] - N' + (N' - 1)[R/x^*(N')] = 0. \quad (8.3)$$

When the prize  $R$  is increased, the effect of prize  $R$  on the lottery sales  $x^*$  and on the net government revenues, respectively, are<sup>8</sup>

$$\frac{\partial x^*(N')}{\partial R} \geq 1, \quad (8.4)$$

$$\frac{\partial G}{\partial R} = \frac{\partial x^*(N')}{\partial R} - 1 \geq 0. \quad (8.5)$$

As shown in equations (8.4) and (8.5), increasing the prize does not reduce the sales  $x^*$  and the governmental net revenue  $G$ , but it is unclear here whether the prize definitely increases  $G$ . Hence, it is necessary to clarify this property empirically.

We can consider that  $R=0$  in areas where the lottery receipt experiment is not being conducted; thus Equation (8.5) can express the difference in tax revenues between areas where the experiment is and is not being conducted. Moreover, comparison within the areas of the experiment is also possible, and according to Equation (8.5), the tax revenue in areas of the experiment with large prizes is likely to be larger than (or equal to) that in areas of the experiment with lower prizes. Section 3 examines the effect of the lottery receipts, in other words, whether  $\frac{\partial G}{\partial R} \geq 0$  is true.

Fig. 8.5 shows the framework of the delivery of lottery receipts, and the behaviors of the government, the firm, and the consumer.

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<sup>8</sup>See Morgan (2000) for details.

## 8.3 Empirical Examinations

### 8.3.1 Probability of Winning a Prize, Amount of Prize, and the Data Set

To announce the amount of the prize beforehand can be considered a strategy of the government. For example, according to the pre-draw prize announcement<sup>9</sup> by the Beijing Local Tax Bureau on July 17, 2002, total prize money amounted to three million Renminbi in August and September, and 10 million Renminbi between August and December 2002. However, ex post facto, the total prize money paid out to the 67,129 winners in the whole city during 2002 was 1.67 million Renminbi. The total actual prize was therefore only 16.7 percent of the announced prize.<sup>10</sup> Moreover, the pre-drawing prize announcement of the probability of winning the prize (namely, the ratio between the prize and the tax revenue) is a strategy of the government.

According to a report<sup>11</sup> of the China Taxation Bureau on July 30, 2002, the total prize amount paid out in all of the experimental areas throughout China was 30 million Renminbi, and the increase in tax revenues brought about by the lottery receipts was 900 million Renminbi between January 1 and June 30, 2002. The ratio of the prize to tax revenues (which can be seen as a kind of input output ratio) was about 1:30. In the experiment in the Huairou District of Beijing in 2001, 0.14 million Renminbi was paid out in prizes and the tax revenue of six million Renminbi was increased owing to providing a receipt with lottery purchases. The prize tax revenue ratio was about 1:40. Many Chinese mass media outlets announce information regarding the prizes. We cannot obtain detailed information on prizes at the provincial or state level for the entire country, thus we cannot perform an econometric analysis at the provincial level.

There are 18 districts in Beijing. Huairo, Chaoyang, Shunyi, Fengtai, Fangshan, Pinggu, Shijingshan, and Miyun have issued receipts with lottery transactions since August 1, 2002. The other ten districts began issuing receipts on October 1, 2002. Therefore, the effect of the experiment on tax revenues can be estimated by district-level panel data (18 districts, 5 years, before and after the experiments).

Tianjin has issued receipts with lottery purchases only since January 1,

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<sup>9</sup>See “Beijing Evening on July 17, 2002” for details.

<sup>10</sup>This may also be because the planned sale of lottery x\* was not realized.

<sup>11</sup>See ‘People’s Daily’, July 31, 2002 for details.

2004. Tianjin is adjacent to Beijing both geographically and culturally. They are both cities under the direct control of the central government. According to Table 8.2, the populations, city scale, and income of these two cities are very similar. Therefore, we used Tianjin as a control area for a comparative analysis of before and after the experiments in Beijing. We obtained detailed information on the experiments, such as prize amounts and tax revenues, from the Tianjin Statistics Bureau, Tianjin Tax Bureau, Beijing Statistics Bureau, and Beijing Tax Bureau<sup>12</sup>. Therefore, we used the 5-year district-level data (18 districts in Beijing and 21 districts in Tianjin) to empirically examine the effect of experiment.

Summary statistics of the data are reported in Table 8.3. The main information before and after the experiments is summarized by district in tables 8.4-8.6. These four tables provide some indication of the effects of the experiment.

### 8.3.2 Specification for the Empirical Model and Methods

Following Heckman and Hotz (1989), Papke (1994) and Wooldridge (2002), we used the following empirical model (random growth model) to capture the effect of the experiments (Equation (8.5)), and obtained

$$y_{it} = c_i + \beta LRE_{it} + g_i t + u_{it}, \quad (8.6)$$

where  $y_{it}$  is the log value of per capita real operating tax revenue in district  $i$  and the information from the lottery receipt experiment ( $LRE_{it}$ ),  $g_i$  is the specific trend in the district,  $c_i$  is the specific time-invariant factor, and  $u_{it}$  is the white noise; they are all unobserved. The first difference of Equation (8.6) becomes

$$\Delta y_{it} = \beta LRE_{it} + g_i + \Delta u_{it}. \quad (8.7)$$

For a consistent estimator of  $\beta$ , the important condition is that the  $LRE_{it}$  is exogenous. As pointed out in Heckman and Hotz (1989) and Papke (1994), if there is a problem of self-selection regarding program participation, it is very hard to obtain a consistent estimator of  $\beta$ . As everyone knows, China

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<sup>12</sup>Beijing Statistic Yearbook 1999-2003, Tianjin Statistic Yearbook 1999-2003 and China Statistic Yearbook 1999-2003 are used.

is a centralized country, and policy changes cannot occur in a state or a city unless the central government grants permission; moreover, no state or city has the freedom to accept or reject central government policy. Therefore, it can reasonably be said that  $LRE_{it}$  is exogenous. Moreover, because all of the samples used in the econometric analysis are areas that participated in the experiment, by using experiment information for different periods we can avoid the problem of self-selection and obtain a consistent estimator of the effect of the experiment.

Because error term  $\Delta u_{it}$  is the one difference of  $u_{it}$ , it becomes a series correlation<sup>13</sup>. The fixed effect of panel estimation considering this characteristic of the error term is used to estimate Equation (8.7). This method is explained in detail in Papke (1994) and Wooldridge (2002).

### 8.3.3 Variables used in the Empirical Tests

$\Delta y_{it}$  is the one difference of  $y_{it}$  which is the log value of per capita real operating tax revenue in district  $i$  and is the dependent variable.  $\Delta LRE_{it}$  is the dummy variable for an experiment district (1 for an experiment district, 0 for others) multiplied by the dummy variable for the experiment time (1 for experiment time, 0 for other time).  $\Delta LRE_{it}$  is the independent variable.  $\Delta Prize_{it}$  is the one difference of per capita real lottery prize; it is considered a proxy for capturing the experiment effect ( $\Delta LRE_{it}$ ) and is an independent variable.

## 8.4 Estimated Results

The estimated results are reported in Tables 8.7, 8.8, and 8.9. The dependent variable is the logarithm of tax revenues, and the independent variable is the dummy; thus the value of the estimated coefficient serves as the difference in the growth rates between experiment and non-experiment areas.

Table 8.7 is the result of panel estimation based on the information for 18 districts in Beijing. For total revenue, the effect of the experiment was not significant, although there was a 3.8 percent increase. In the case of operating tax, growth rates were significantly (23.5 percent) higher in experiment areas than in non-experiment areas. The significance of the coefficient did not

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<sup>13</sup> $Corr(\Delta u_{it}, \Delta u_{it-1}) = -0.5$ . See page 283 of Wooldridge (2002) for details.



change with a policy dummy when using the prize as a proxy, although it is hard to compare these two absolute values of the coefficient.

Table 8.8 shows the results of panel estimation based on the information for the 17 districts in Beijing. In eight districts, the experiment started in August 2002 and had lasted 5 months by December 2002, while in the other 10 districts the experiment started in October 2002 and had lasted three months by December 2002. Because the experiment in Huairou started in January 2001, this district was removed from the sample. A comparative analysis of the 17 districts was performed. The results are very similar to those in Table 8.7. The effect of the experiment on total tax revenues was not significant, although there was a 2.2 percent increase. In the case of operating tax, there was about a 23.6 percent difference in the growth rates of the two groups of experiment areas. This result does not change with the tendency of the significance of the estimated coefficient in the case using the prize as proxy.

Table 8.9 shows the results of panel estimation based on the information for Tianjin and Beijing (18 districts in Beijing and 21 districts in Tianjin). The results in Table 8.8 are also very similar to those in Table 8.7.

## 8.5 Conclusion

This paper examined, theoretically and empirically, the experiment of issuing a receipt with lottery purchases in China. When the revenue from the lottery is used to finance the public good, according to the proposal of Morgan (RES, 2000), even if a consumer has expected utility with quasi-linear preference, he or she will purchase a lottery ticket. By issuing receipts, the Chinese government can prevent the tax evasion caused by collusion between firms and consumers and can collect operating taxes effectively to some extent. Our empirical examination of 5-year data from 39 districts in Beijing and Tianjin indicated that the real growth rate of operating tax was significantly (23.5 percent) higher in experiment areas than in non-experiment areas. Moreover, because the data sets used were all from of areas that participated in the experiments, and because the estimations were based on different periods of participation, self-selection problems were avoided. Our analysis is similar to a kind of natural experiment.

The Chinese economy in the 20th century was quite experimental; for example, there was the socialist economy experiment, the market economy

experiment, and the experiment with lottery receipts. By means of these experiments, the Chinese economy has both stagnated and grown. Although it is natural that some experiments will fail to an extent, it is obviously necessary to avoid failure if possible. Through the analysis of the data sets conducted in this study, the lottery receipt experiment can be judged as successful insofar as it increased operating tax revenues. Certainly, this new system of taxation will have a significant influence on future tax collection policies in China, and perhaps in other countries as well.

In future research, we must clarify theoretically and more specifically consumer preference for lottery ticket purchases and empirically apply those data to the information from the experiment and non-experiment areas for 2003. Moreover, we must obtain nationwide information and perform detailed analyses based on individual data, including attitudes toward the lottery receipt system. Additionally, because playing the lottery is a form of gambling, we must consider the social cost of gambling in relation to social welfare<sup>14</sup>.

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<sup>14</sup>However, the tax evasion is penalized in every country when it is detected by government, thus the tax evasion is also a form of gambling.

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## 8.7 Figures

## 8.8 Tables

## Chapter 9

# Is the Life-Cycle Model or Ono's Model Most Suitable for the Japanese?: Analysis by Time-Series Data and Surveys of Lottery Purchase and Large-Prize Winners

JEL classification: E12, E24, E41; Keywords: insatiable wealth preference, life-cycle, lottery, prize winner

### 9.1 Introduction

The existence of persistent unemployment has been hotly debated by neo-classical and Keynesian economists. Neoclassical theory denies the existence of persistent unemployment, instead only acknowledging temporary unemployment as part of the business cycle. On the other hand, Keynesians strongly insist on the existence of persistent unemployment, despite the fact that adequate microeconomic foundations have not yet been provided for it. In an attempt to compensate for this deficiency in the economic literature, Ono (2001) proposed a micro foundation for such unemployment using the standard money-in-utility-function model (MIUF). The MIUF has been em-

pirically tested by many economists; for example, Poterba et al. (1987) and Holman (1998) found some evidence supporting the MIUF. However, Ono (2001) has also been criticized, because insatiability of liquidity or wealth (hereafter “the Ono hypothesis”) is a necessary condition of the model. This assumption of insatiability has rarely been supported empirically, with one exception, namely Ono et al. (2004). Ono et al. (2004) performed two estimations. The first was a parametric estimation employing time-series data, while the second provided a nonparametric estimation using cross-sectional data on individuals. Ono et al. (2004) found that the hypothesis of the insatiability of money or wealth was supported in the case of Japan.

In this paper, we use parametric and nonparametric methods and four unique data sets to clarify whether and what fraction of the Japanese is insatiable with respect to money or wealth. In particular, we obtain striking results. Using annual Japanese data, we obtain evidence in support of the Ono hypothesis. In addition, using data from four micro surveys, we find that about 64.4 percent of Japanese participated in a lottery prior to 2003, and that about 51.5 percent of Japanese bought lottery tickets in 2003. In addition, 59.3 percent of lottery participants indicated that they bought tickets in the hope of winning the prize, despite the fact that the expected return to the lottery was negative. Individuals of an intermediate level of education were more likely to buy lottery tickets. Middle-income individuals were also more likely to participate, and this fact is consistent with the prediction of Friedman et al. (1948). More than 46 percent of large-prize winners did not change their lifestyles, but 54 percent did make lifestyle changes after receiving a large prize (the magnitude of which was more than twice the average value of per Japanese household assets). On average, 60.85 percent of the largest-prize (8.26 million yen) winners increased their consumption, and their behavior was thus consistent with the life-cycle model. However, 39.15 percent (or 52.35 percent, if land and housing, work and business, and investments are considered assets) of the largest-prize winners did not increase their consumption; the behavior of these individuals thus strongly suggests that the life-cycle model is inappropriate for the Japanese while instead providing support for the Ono hypothesis. Hence, if economic stimulation is to ease the current recession in Japan, consumption taxes or fiscal expenditure may be preferable to income or wealth tax cuts.

The remainder of the study is structured as follows. Section 2 introduces the theoretical framework. Section 3 presents the methodology and data sets. Section 4 reports the results, while Section 5 concludes and discusses policy



implications.

## 9.2 Theoretical Framework

### 9.2.1 Model

A representative consumer is assumed to maximize his lifetime utility by choosing his levels of consumption and money holding.

$$\max_{c_\tau, m_\tau} V_t = E_t \sum_{\tau=t}^{\infty} \theta^{\tau-t} U\{c_\tau, m_\tau\} \quad (9.1)$$

$$\begin{aligned} \text{Gamma s.t. } A_\tau &= (1 + R_{\tau-1}^B)A_{\tau-1} + (1 + R_{\tau-1}^M)M_{\tau-1} - P_\tau c_\tau - P_\tau m_\tau \\ a_\tau &= b_\tau + m_\tau \end{aligned}$$

$E_t$  denotes the expectation operator conditional on information in period  $t$ .  $c_\tau$  denotes real consumption.  $m_\tau$  and  $A_\tau$  respectively denote real money holdings and total nominal assets at the beginning of period  $\tau$ .  $R_{\tau-1}^B$  and  $R_{\tau-1}^M$  are the nominal interest rate on bonds, and money, at time  $\tau - 1$ .  $\theta \in (0, 1)$  is the discount factor, where  $\theta = 1/(1 + \rho)$ , and the additively time-separable constant  $\rho$  represents the time preference of the consumer. The consumer is further assumed to have full current-period information.

In this context, the Bellman equation is given by

$$\begin{aligned} V(a_t) &= \max_{c_t, m_t} \{U(c_t, m_t) + E_t[\theta V(a_{t+1})]\} \\ \text{s.t. } A_\tau &= (1 + R_{\tau-1}^B)A_{\tau-1} + (1 + R_{\tau-1}^M)M_{\tau-1} - P_\tau c_\tau - P_\tau m_\tau \\ \text{T.V.C. } \lim_{j \rightarrow \infty} \theta^j a_j &= 0. \end{aligned} \quad (9.2)$$

In addition, the solutions to the Bellman equation are given by

$$E_t \left[ \theta \frac{\partial U_{t+1} / \partial c_{t+1}}{\partial U_t / \partial c_t} \frac{P_t}{P_{t+1}} (1 + R_t^B) - 1 \right] = 0, \quad (9.3)$$

$$\frac{\partial U_t / \partial m_t}{\partial U_t / \partial c_t} - \left( \frac{R_t^B - R_t^M}{1 + R_t^B} \right) = 0. \quad (9.4)$$

## 9.2.2 Specification of Utility Function for Parametric Estimation

Following Wan (2001), we assume that the utility of consumption is additively separable from that of money. In particular,  $U(c_t, m_t) = u(c_t) + v(m_t)$ ,  $u(c_t) = (1 - \gamma)^{-1}(c_t^{1-\gamma} - 1)$ , and  $u(m_t) = \beta m_t + \alpha[(1 - \eta)^{-1}(m_t^{1-\eta} - 1)]$ . When these special utility functions are substituted into equations (9.3) and (9.4), we obtain

$$E_t \left[ \theta \left( \frac{c_t}{c_{t+1}} \right)^\gamma \frac{P_t}{P_{t+1}} (1 + R_t^B) - 1 \right] = 0, \quad (9.5)$$

$$\left( \frac{R_t^B - R_t^M}{1 + R_t^B} \right) \left( \frac{1}{c_t} \right)^\gamma - \alpha \left( \frac{1}{m_t} \right)^\eta - \beta = 0. \quad (9.6)$$

This system of two equations is estimated in the following section by means of annual Japanese data.

## 9.2.3 Specification for Nonparametric Estimation

Substituting Equation (9.3) into Equation (9.4), we get

$$E_t \left[ \frac{\partial U_t / \partial m_t}{\partial U_{t+1} / \partial c_{t+1}} \frac{P_{t+1}}{P_t \theta (R_t^B - R_t^M)} - 1 \right] = 0. \quad (9.7)$$

An expression for the marginal effect of money may be obtained by differentiating Equation (9.7) with respect to  $m_t$ , as follows<sup>1</sup>:

$$E_t \left[ \frac{\partial c_{t+1}}{\partial m_t} \right] = E_t \left[ \frac{\partial u(c_{t+1}) / \partial c_{t+1}}{\partial v(m_t) / \partial m_t} \frac{\partial^2 u(m_t) / \partial m_t^2}{\partial^2 u(c_{t+1}) / \partial c_{t+1}^2} \right], \quad (9.8)$$

$$= 0, \text{ if and only if } \partial^2 u(m_t) / \partial m_t^2 = 0; \quad (9.9)$$

$$(\partial u(m_t) / \partial m_t = \text{constant}), \quad (9.9)$$

$$> 0, \text{ if and only if } \partial^2 u(m_t) / \partial m_t^2 < 0. \quad (9.10)$$

The intuition behind equations (9.8), (9.9) and (9.10) is as follows. If a consumer increases his consumption upon experiencing a positive exogenous money or wealth shock, then his behavior provides support for Equation (9.10) (consistent with the Life Cycle Model); however, if instead he does not increase his consumption after the positive wealth shock, his behavior rather supports Equation (9.9) (consistent with the Ono's hypothesis).

<sup>1</sup> $\partial u(c_{t+1}) / \partial c_{t+1} > 0$ ,  $\partial^2 u(c_{t+1}) / \partial c_{t+1}^2 < 0$ ,  $\partial v(m_t) / \partial m_t > 0$  are assumed.

## 9.3 Methodology and Data

### 9.3.1 Methodology

Following Hansen (1982) and Hansen and Singleton (1982), the System Generated Moment Method (GMM) is employed to estimate the parameters. A J-test is also used to test the overidentification restrictions. Mao (1990) pointed out that the estimator in this case is sensitive to the lags of instrumental variables (IV) and that, therefore, a lower IV lag is preferred. In this study, we follow this suggestion. In addition, GMM requires the stationarity of both the primary variables and the instruments, so we make use of unit root tests to ensure that all variables are stationary.

When using the individual data, we perform probit estimations and interval regressions to determine which individuals participated in the lottery. We also use graphs and tables to illustrate the behavior of the prize winners.

### 9.3.2 Time-Series Data

Annual data for the period from 1965 to 1996 are likewise examined. In this case,  $R_t^B$  denotes the nominal return to stock investment, as determined by the Institute of Japanese Stock and Economic Research. Similarly,  $C_t$  denotes final nominal household consumption expenditure, as taken from the Report on National Accounts of the Economic and Social Research Institute, Cabinet Office, Government of Japan.  $M_t$  denotes nominal household financial assets (i.e., cash, demand deposits, and postal savings), as taken from Flow of Funds Accounts, Bank of Japan.  $P_t$  is the GDP deflator, which is taken from National Accounts;  $N_t$  represents the total population of Japan and is obtained from the Monthly Report on Japanese Population. Finally,  $R_t^M$  is the interest rate on postal savings, which is taken from Monthly Economic Statistics.

The variables  $c_t$  and  $m_t$  are processed according to  $C_t$ ,  $M_t$ , and  $P_t$ .

### 9.3.3 Individual Data

We have four individual data sets deriving from lottery surveys. The first lottery survey, which was conducted by the Japanese Lottery Association, began in 1976 and was performed every three years thereafter. The tenth

survey of this group took place in April 2004. The population surveyed comprised Japanese ages 18 and over. Of the 9,304 surveys randomly distributed, 6,557 were completed. We say that a person was a lottery participant if he participated within the previous year, and that a person was an experienced buyer if he had experience as a lottery participant. Figure 9.1 illustrates both participants and the experienced. Strikingly, the numbers of both have increased up to the present, in spite of the period of recession following the burst of the economic bubble. In 2003, the experienced numbered 71.5 million, or 68.4 percent of the Japanese population, while participants numbered 53.8 million, or 51.5 percent of the population. We also obtained information on total lottery ticket sales and the values of the largest prizes awarded from the Japanese Lottery Association. Figure 9.2 illustrates the data for these two groups of individuals for the period 1945-2003. It is evident that both classifications of lottery enthusiast have continuously increased.

The second survey used is the Japanese Pachinko Survey, which was conducted by the Ace Research Institute. This survey was also random, and the survey population again comprised Japanese ages 18 and over. Not only pachinko participation, but also participation in other gambling activities, such as the lottery, were surveyed, with a total of 2,575 respondents. The frequency of lottery ticket purchase is illustrated in Figure 9.3. The percentages of buyers and the experienced in this case were very similar to those in the case of the Survey on the Lottery performed by the Japanese Lottery Association. Thus, the Japanese Pachinko Survey and the Survey on the Lottery were sufficiently precise to capture lottery participation in Japan. The Japanese Pachinko Survey also surveyed buyer education and income, while these demographics were not collected under the Survey on the Lottery; thus the two surveys can be used together for the purpose of testing various economic hypotheses. The individual data obtained from the 2001 Japanese Pachinko Survey are thus used to clarify the effect of income and education on lottery ticket purchases.

The third survey used in this investigation is the 2003 Survey of Lottery Prize Winners, which was conducted by Mizuho Bank. Mizuho Bank is the corporate organization that administers the sale of lottery tickets and the remuneration of winners. In 2003, 15,399 winners won prizes worth over one million yen, and 3,188 of these winners won prizes worth more than ten million yen. In recent years, Mizuho Bank has surveyed every large-prize winner during the collection of his prize. During the 2003 fiscal year, 6,001 respondents answered the relevant questionnaire.

The fourth survey examined comes from the 2003 White Paper on Large-Prize Winners, which was likewise produced by Mizuho Bank. In this case, 1,495 respondents, whose prizes were worth more than ten million yen, were surveyed. The 2003 Survey of Lottery Prize Winners and this 2003 White Paper on Large-Prize Winners were used to test the relevancy of the life-cycle model and the Ono hypothesis.

## 9.4 Results

### 9.4.1 Time-Series Data

The GMM estimation results are summarized in Table 9.1.  $\theta$ ,  $\alpha$ ,  $\gamma$  and  $\eta$  are all significantly positive and take on reasonable values. The key parameter of interest,  $\beta$ , is also significantly positive. This evidence is consistent with the Ono hypothesis, which suggests that the Japanese consumer is insatiable with respect to money or wealth<sup>2</sup>.

### 9.4.2 Results from Individual Data

First, consider Table 9.2, which is derived from the 2004 Survey on the Lottery taken by the Japanese Lottery Association. This table illustrates the reasons why consumers chose to participate in the lottery. The most common responses, “I wanted the lottery prize” and “I had a dream about the lottery,” accounted for 59.3 and 50.6 percent of respondents, respectively. According to a report made by the Japanese Lottery Association in 2004, the price of one lottery ticket was determined in three parts: 39.8 percent of the price was a lottery tax, 14.2 percent of the lottery price was the cost of making and selling lottery tickets, and 46.0 percent of the lottery price was used to fund the lottery prize. Thus, when the buyer purchased one lottery ticket, he faced a negative expected return corresponding to 54 percent of his outlay. Furthermore, the fact that buyers nonetheless purchased tickets because they dreamed about the lottery or simply wanted the prize cannot be explained by standard economic theories, such as the expected utility framework with risk aversion. The behavior of Japanese consumers was thus either paradoxical or irrational.

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<sup>2</sup>If  $\beta$  is sufficiently small, then the life-cycle model is also supported in the case that the consumer is not sufficiently wealthy. See Ono (2001) for details

Second, consider Table 9.3. This table presents three sets of estimation results clarifying the identity of participants and the frequency of their participation in the lottery. The first column describes lottery participants by means of a probit (1 for experienced, 0 for unexperienced), while the second column provides similar results from an estimation incorporating also the level and square of weekly allowance. The coefficients on *high\_school*, *tech\_school*, and *university* are all significantly positive. The coefficient on *income\_600800* is likewise significantly positive. These results imply that *middle\_income* individuals were more likely to have experience of lottery participation. The third column presents results from an interval regression (the dependent variable derives from interval data in this case) clarifying the frequency of lottery participation. In terms of the frequency of purchase, those respondents having at least a college education were less likely to participate than those with less than a high-school education. Moreover, the coefficient on the highest income variable, *income\_over1500*, is negatively significant. Other proxies used in place of buyer income include the level and square of *weekly\_allowance*. The coefficient on *weekly\_allowance* is positive and significant, but the coefficient on the square of weekly allowance is not significant. This evidence is consistent with the prediction of Friedman and Savage (1948) <sup>3</sup>.

Third, consider Table 9.4. This table presents information regarding who the recipients of large prizes (worth over one million yen) chose to inform of their winnings, as based on the 2003 Survey of Large-Prize Winners conducted by Mizuho Bank. In general, the winner most often chose to share this information with his spouse. However, 24.7 percent of winners kept the information to themselves, perhaps for fear of losing part of the benefit upon announcing the prize.

Fourth, Table 9.5 indicates the identity of large prize winners. The first column in this table indicates that 6,001 respondents each received prizes worth at least one million yen, while the second column indicates that 1,495 respondents received prizes worth at least ten million yen, in 2003. The demographics of these samples are summarized by sex, age, and career. No large differences are apparent between the two columns.

Fifth, Table 9.6 presents winner lifestyle changes resulting from the prize.

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<sup>3</sup>Friedman et al. (1948) proposed a concave-convex-concave utility function with respect to income or wealth. Within this framework, one may predict that middle-income individuals should be more likely to participate in the lottery.

The first column provides the responses of the full sample (6,001 respondents). The remaining columns provide answers for recipients of 1-3 million yen prizes, through recipients of 100-400 million yen prizes. Note that 60.7 percent of respondents in the full sample did not make any lifestyle changes. This is a striking result. Even in the eighth column, in which the average prize was about six times the net average for Japanese household assets in 1999 (see Ogawa and Wan (2004)), 46 percent of the winners made no changes in their lifestyles. This observation cannot be explained well by the life-cycle model, though it is consistent with the Ono hypothesis. The behavior of respondents who did increase their degree of family service, enriched their leisure time, increased their filial devotion to their parents, increased their acquaintances, got married, or altered their job or retirement status, is well explained by the life-cycle model. In particular, increases in family service, filial devotion to parents, and getting married appear to have been normal goods, while acquaintances may have been inferior.

Sixth, Table 9.7 provides information on how the prize winnings were to be used. The first column provides the answers of 6,001 respondents, while the third column presents those for the 1,495 respondents with higher winnings. The average prize received by respondents in the first column was 8.26 million yen, while the corresponding figure in the eighth column was 23.18 million yen. Thus, the results in Table 9.7 provide a direct measure of the impact of the income effect on expenditure and saving (equations (9.9) and (9.10)). The saving rate of respondents increased remarkably (by about a factor of two) when the prize amount rose from 8.26 million yen to 23.18 million yen. The purchase of land and housing rose from 5.4 percent to 28.4 percent, and this increase implies that land and housing were considered normal goods (furthermore, as land and housing are two different types of asset, the imputed rent corresponds to consumption). Education and culture, cars, beauty and health, and donations and social contributions were also considered normal goods. However, preferences with regard to food, clothes, accessories, and traveling were not immediately clear, though these may have been considered inferior goods. A summation of the information in the first column, excluding saving and loan repayments, yields an estimate of 86.8 percent, which means that over 13.2 percent of respondents did not increase their consumption, even when receiving an 8.26-million-yen prize. This observation suggests that the life-cycle model may not be appropriate in this case and rather provides support for the Ono hypothesis. In addition, as indicated by the first column of Table 9.7, if the respondents who

chose to save were different from those who chose to repay loans, but if they likewise chose not to increase their consumption, then a maximum of 65.1 percent of Japanese could be inferred as behaving in a manner consistent with the Ono hypothesis. Thus, 39.15 percent (13.2 percent at a minimum, 65.1 at a maximum) of Japanese on average did not behave in accordance with the life-cycle hypothesis; rather, their behavior was consistent with the Ono hypothesis. Alternatively, if land and housing, work and business, and investments are also considered assets, then the confidence interval ranges from 26.4 percent to 65.4 percent. On average, the behavior of 52.35 percent of respondents undermines the life-cycle hypothesis but supports the Ono hypothesis. Certainly, even if some fraction of respondents chose to increase their consumption but this fraction were sufficiently small, then the behavior of these people would also be consistent with the Ono hypothesis.

## 9.5 Conclusions and Policy Implications

### 9.5.1 Findings

Using the GMM and Japanese time-series data, we tested the MIUF model and the Ono hypothesis. The resulting evidence supports not only the MIUF model, but also the Ono hypothesis, which suggests that the Japanese consumer is insatiable with respect to money or wealth.

In the course of this analysis, we used two national surveys taken from two different organizations to clarify the characteristics and participation frequency of lottery participants. Participants indicating that they purchased lottery tickets because they “wanted the lottery prize” or “had a dream about the lottery”, respectively, accounted for 59.3 and 50.6 percent of respondents. When a buyer purchased one lottery ticket, he faced a negative expected return equivalent in magnitude to 54 percent of his financial outlay. Thus, participation in the lottery cannot be explained by standard economic theory, such as the expected utility framework with risk-averse agents. Respondents with a *high\_school*, *technical\_school*, or *university* education were more likely to have experience of lottery participation. Similarly, respondents with *income\_600800* were also more likely to have experience of lottery participation. In terms of the frequency of purchase, respondents with a college education were less likely to buy tickets than those having less than a high school education. The respondents with the highest incomes



were also less likely to participate in the lottery, and this income effect on lottery purchase is consistent with the prediction of Friedman and Savage (1948).

We also made use of two surveys of prize winners to clarify their behavior after they received large prizes and test whether the life-cycle model or the Ono hypothesis was best supported. The winner's spouse was usually informed of the prize receipt, but 24.7 percent of winners did not tell anyone that they had won. The behavior of respondents who did increase their family service, enriched their leisure time, increased their filial devotion to their parents, increased their number of acquaintances, got married, or altered their job or retirement status, is well explained by the life-cycle model. In addition, family service, filial devotion to parents, and getting married were considered normal goods, while acquaintances seem to have been considered inferior goods. Forty-six percent of winners did not make any lifestyle changes. This observation cannot be well explained by the life-cycle model but is consistent with the prediction of Ono.

Land and housing were considered normal goods. In addition, education and culture, cars, beauty and health, and donations and social contributions were all considered normal goods. However, food, clothes, accessories, and traveling appear to have been considered inferior goods. Over 13.2 percent of respondents did not increase their consumption, even after receiving an 8.26-million-yen prize. This behavior of over 13.2 (39.15, on average) percent of respondents undermines the life-cycle hypothesis and instead provides strong support for the Ono hypothesis<sup>4</sup>. If land and housing, work and business, and investments are considered assets, then on average the consumption behavior of 52.35 percent of respondents rejects the life-cycle model but supports the Ono hypothesis.

## 9.5.2 Policy Implications and Remaining Issues

Because, on average, 39.15 (or 52.35, if land and housing, work and business, and investments are considered assets) percent of Japanese are insatiable for money or wealth and do not behave in the manner predicted by the life-cycle model, the range of policies with potential for effective economic stimulation is limited. In other words, the effects of income and wealth tax cuts are

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<sup>4</sup>Ono (2001) explained persistent unemployment and provided useful advice for overcoming this type of unemployment. See Ono (2001) for details.

likely to be limited or very weak, while a consumption tax<sup>5</sup> or increased fiscal expenditure should be more effective.

Several issues are left for future research. In the context of the time-series analysis conducted, we should extend the time-series and use quarterly and monthly data in the course of estimation, as these data are readily obtainable. In addition, some specification error may be present in the equations estimated, and so we should investigate other functional forms for the utility function. In the context of the individual analysis, we should investigate the fraction of prize winners who did not increase their consumption, as well as obtain detailed explanations of this behavior. For example, we could directly interrogate the winners and ask them why they did not alter their consumption behavior even after winning a large lottery prize. Participant age and asset and debt holdings are also key variables in the context of the life-cycle model and should be controlled for. These latter omissions are likewise left for future investigation.

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<sup>5</sup>This has been discussed by Horioka and Sekita (2004).

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## 9.7 Figures

## 9.8 Tables

# Chapter 10

## Conclusions

### 10.1 Findings, Problems Solved, and Policy Proposals

Numerous findings are reported in Chapters 2-9. I outline them here, briefly, by chapter.

In Chapter 2, the hypotheses of non-addiction, myopia and rational addiction were tested using annual, quarterly, and monthly data. Changes in the price of Japanese cigarettes can be viewed as exogenous from the point of view of consumer behavior, because the Japanese government controls cigarette prices. The empirical results of this paper support the addiction hypothesis. The short-run and long-run price elasticities range from -0.338 to -0.421, and from -0.679 to -0.686, respectively; thus, increases in tax revenues in the long-run are likely to be smaller than those in the short-term. As a result, tax increases would be an effective means of curbing smoking and reducing its social cost. Furthermore, the debt compensation programs for the Japan Railway and the National Forestry will not go according to plan, unless revenues are increased in the future.

In Chapter 3, a rational addiction model with an optimal inventory was developed; this model can be used as a new way to distinguish consumption from purchases at a time when there is perfect foresight concerning price. The theoretical framework was tested using daily and monthly cigarette purchases in Japan. The rational addiction model was not supported when inventory was not considered, as the inventory became an omitted variable and correlated with price, while it was supported if the optimal inventory

was included in the estimating equation. As the tax elasticity of hoarding exceeds 400 percent, a tax increase is considered a good tool for temporary economic stimulation.

Chapter 4 clarified the effects of health information on cigarette consumption and intake of nicotine and tar in the rational addiction (RA) framework. The consumer over-consumes cigarettes because of a shortage of health information, and reduces consumption when new health information is announced. Auld and Grootendorst (2004) have pointed out that the estimable RA model tends to yield spurious evidence when aggregate data are used; if, however, prices are exogenous, instrumental variable estimates will be consistent. The Japanese cigarette price is considered exogenous because it is determined by the government. The RA model with health information is supported by Japanese monthly data and policy events. Robust evidence has also been obtained from Japanese national surveys. The consumer responds to new information by changing cigarette type, or by reducing or quitting smoking. The total intake of nicotine and tar is significantly decreased by the release of nicotine and tar content information. Tobacco control policies, such as cigarette taxes and health information, were shown to be effective, but the effect of health information was bigger than that of a tax increase.

Chapter 5 introduced a new way to examine the effects of mandatory information disclosure on inter-brand cigarette demands, and the behavior of a monopolistic firm in Japan. We estimated inter-brand demands by including nicotine, tar content, and policy event information in the model, and by using cigarette brand sales data. We found that the mandatory disclosure of nicotine and tar content information decreased the intake of nicotine and tar per capita and per smoker; thus, mandatory disclosure is likely to increase consumers' welfare, if we suppose that they always choose their favorite cigarette. Furthermore, we found that the monopolistic firm supplied a greater number of new, and better quality products, and that it discontinued the production of poorer quality goods, and conducted more R & D, in response to disclosure mandates.

In Chapter 6, the following findings were presented. The market volume of the pachinko industry exceeds 28 trillion yen, and its added value is about 0.86 percent of GDP in 1999. According to the report 'Survey of Pachinko Addiction' and 'Survey of Pachinko and the Pachinko-slot Player', pachinko gives rise to two social problems: pachinko addiction (29.3 percent of pachinko addicts think they need medical treatment), and an increased probability of household bankruptcy. Based on the estimation results using



individual data from the “Japanese Pachinko Survey 2003,” the addiction hypothesis, based on pachinko as gambling, was strongly supported. The pachinko player’s experience involved a significant decrease in the desire to stop participation in the future, an increase in the desire to commence re-initiation after quitting, and a decrease in the duration of non-playing after quitting. Thus, regulation policies for pachinko are necessary. The evidence obtained in this study may also be very helpful in a re-consideration of the assumption of risk averse behavior, and in understanding the economic phenomenon of the bubble, etc.

In Chapter 7, I used a unique individual dataset to clarify the relation between pachinko gambling and smoking. I showed that they are positively correlated, and I also showed their causality. Pachinko gambling increases smoking; thus, smoking is complementary to gambling. On the other hand, the desire to play pachinko in premises where a smoking ban is operative decreases, owing to the status of smoking in these premises; thus, pachinko is also complementary to smoking. Because smoking is harmful to health and gambling causes household bankruptcy in Japan (strong negative externalities), some regulation policies (smoking ban, etc.) are needed. Because of their complementarity, the effect of regulation is expected to be greater than usual.

In Chapter 8, I researched a new system of taxation called lottery receipts, which has been operating in China, theoretically and empirically. The budget deficit, mitigation of inequality, etc., and income redistribution have meant that the supply of public goods by an efficient and fair tax collection system has become necessary in China. However, as it is difficult for the government to act as the monitor of actual economic dealings because of information asymmetry, tax collection is not easy. Therefore, in order to bring out private information, known only to a seller and a buyer, the Chinese government has set up a lottery receipt system; this system has been tried out in a number of areas. This study considers the validity of this system, both theoretically and empirically. When the net revenue from a lottery is invested in pure public goods, Morgan (RES, 2000) has shown that public lotteries have been purchased, even if the consumer expected utility with quasi-linear preferences. By this means, the Chinese government hopes to prevent tax evasion caused by conspiracies between firms and consumers, and to collect tax effectively, to some extent, by issuing a receipt with a fixed-prize lottery ticket. In the empirical analysis, estimation that avoided self-selection was performed based on panel data for different periods from a total of 39 districts

in Beijing and Tianjin, since 1998, when the experiment started. This study finds that the receipt with lottery system has significantly increased the real growth of operating tax.

In Chapter 9, the linkage between the traditional life cycle and Ono's model was analyzed; subsequently, they were theoretically and empirically tested using time series data and surveys on lottery buyers and prize-winners. Using GMM and Japanese annual data, evidence was obtained that supports Ono's hypothesis, which implies that the Japanese consumer is characterized by an insatiable desire for money and wealth. In addition, four surveys were used to clarify who buys lottery tickets, and why, and to determine what the winners do after obtaining their prize. The reasons why individuals buy lottery tickets have been identified as, 'I want the lottery prize', and 'I had a dream about the lottery', according to 59.3 and 50.6 percent of respondents, respectively. Those in the middle income bracket are more likely to have had experience of lottery ticket purchase. Usually, a wife or a husband will receive news of a big win, but 24.7 percent of winners tell nobody. Forty-six percent of winners do not change their lifestyle after winning the lottery. On average, 39.15 (if land and housing, work and business, and investment are considered assets, averaging 52.35) percent of respondents do not increase their consumption, even if they are awarded the 8.26 million yen prize. This kind of behavior on the part of Japanese lottery winners strongly rejects the life cycle hypothesis, but supports Ono's hypothesis, while the behaviors of 60.85 percent of Japanese support the life cycle model. Thus, the effects of an income tax cut and a wealth tax cut on economic stimulation are limited or weak; a consumption tax and fiscal expenditure are expected to be more effective. An increase in family service, filial devotion to parents, and getting married are superior goods; land and housing, education and culture, the purchase of car, beautification and health, leisure time, job change or retirement status, and donations and social contributions are also superior goods. Food, clothes, and accessory traveling are unclear categories, but seem to be inferior goods.

## **10.2 Issues Remaining for Future Research**

In Chapter 2, the models do not deal with the effects of advertising, public knowledge about the health hazards of smoking, education, and demography, etc. In fact, data for these variables are not currently available. In Chapter

3, consumers' response to health information is not analyzed. In Chapter 4, the welfare change arising from increased price and health information is not analyzed in detail.

In Chapter 5, there are two major issues that have not been addressed in this study. The first is that the addictive nature of smoking was not considered in the estimated model. It would be interesting to introduce the effect of information disclosure into the frameworks of Becker et al. (1994) or Wan (2002c). The second issue is that the approach of Yen and Chern (1992) should be used to estimate information effects.

In Chapter 6, the player's 'rationality' is not tested. To test this, some tax or price shocks are needed. In Chapter 7, the stability of the preference of the gambler and simultaneous smoker is not tested, and the addictiveness of the two goods has not been tested simultaneously.

In Chapter 8, consumers' preference with regard to lottery ticket purchases, on an individual basis, should be theoretically clarified to a finer degree; this should be empirically tested also, using information on the experimental and non-experimental areas from 2003, as well as nation-wide information, and detailed analysis, based on individual data that include negative attitudes to the receipt with lottery system, etc. Moreover, as purchasing lottery tickets is a form of gambling, it is necessary to take the social cost of gambling into consideration in discussions of social welfare in this context.

In Chapter 9, some issues for future research were noted. With respect to the time series analysis, we should extend the time series and use quarterly and monthly data, given that they are easily obtained. Additionally, there may be some specification errors in the equations; therefore, we have to try other forms of the utility function. In the individual analysis, we need to know the number of prize-winners who did not increase their consumption, and the reasons for this, in detail. One way to approach this is to ask direct questions concerning their reasons for not changing their consumption patterns after receiving a large lottery win. Age, asset holdings, and debt levels, etc. are also key variables that should be used to test the Life Cycle model, and should be controlled. These matters are left for future studies.

Finally, it is expected that yet more explanations and causalities will be researched and presented in the future.

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