MEASURING INTERTEMPORAL SUBSTITUTION IN CONSUMPTION: EVIDENCE FROM A VAT INCREASE IN JAPAN

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Abstract—We estimate the intertemporal elasticity of substitution in consumption (IES) using a preannounced increase in Japan's consumption tax rate. Because this tax is highly comprehensive, the rate increase was announced prior to its implementation, and because other factors that affect the real interest rate were constant, the tax rate increase presents an ideal natural experiment to estimate the IES. A Japanese monthly household survey is exploited to accurately categorize nondurables, and our empirical specification addresses intratemporal substitution bias. We find that the IES is 0.21 and not significantly different from 0, but it is significantly less than 1.

I. Introduction

IN this paper, we estimate the intertemporal elasticity of substitution in consumption (IES) using an increase in the Japanese consumption tax rate as a natural experiment. The consumption tax, which is a value-added tax (VAT), increased from 3% to 5% in April 1997. Unlike VAT in many other countries, Japan has a single flat rate with a relatively small number of exemptions. As expected, the tax burden was borne fully by consumers in the form of higher prices. Because nominal interest rates and the inflation rate were constant around the implementation of the tax rate increase, it can be treated as an exogenous change in the real interest rate, which provides an ideal situation to estimate the IES.

Previous research on this topic (Hall, 1988; Attanasio & Weber, 1993, 1995; Ogaki & Reinhart, 1998) has relied on an instrumental variables approach to address the critical econometric problem that the real interest rate is endogenous in the standard log-linearized Euler equation for consumption. However, as Yogo (2004) notes, asset returns are notoriously difficult to predict, and as a result, the available instruments are weak. Weak instruments can lead to biased estimators and finite sample distributions of test statistics that depart greatly from their limiting distributions. This paper avoids the problem of weak instruments by exploiting the natural experiment presented by the consumption tax rate increase.

In addition to the novel research design, our data set plays an important role in estimating the IES. We use the Japanese Family Income and Expenditure Survey (JFIES),

a monthly household-level panel data set. Given our use of microdata, our results are free from the aggregation bias discussed in Attanasio and Weber (1993, 1995). Its high-frequency (monthly) panel structure allows us to adopt the conventional Euler equation approach and observe consumption expenditure immediately before and after implementation of the tax rate increase.

Moreover, because the JFIES is highly disaggregated by item type, we can define nondurables appropriately. The definition in previous studies has included goods and services that exhibit some degree of storability or durability. For example, as Mankiw (1985) points out, footwear and clothing are usually considered to be nondurables, but they should be classified as durables. Attanasio and Weber (1993, 1995), the first to address this issue, exclude durables and semidurables but pay little attention to storability. Storable goods can be stockpiled during low-price periods for consumption in high-price periods. Failing to account for this behavior could bias the estimate of the IES upward. To avoid these biases, we separate nonstorable nondurable goods and services (e.g., eating out) from storable nondurable (e.g., laundry detergent) and durable (e.g., automobiles) goods and services.

With multiple goods, we explicitly consider intratemporal substitution between nondurables, storables, and durables by constructing a model of consumer choice. As Ogaki and Reinhart (1998) demonstrate, failing to account for intratemporal substitution can induce a biased estimate of the IES when preferences over nondurables and durables are nonseparable. In general, the service flow from durables becomes higher prior to a tax rate increase because the user cost of durables falls. With nonseparable preferences, households substitute between nondurables and durables. If we do not control for this, the estimate of the IES will be biased, where the sign of the bias depends on the structure of intratemporal preferences. The empirical specification derived below, consistent with our model, is robust to the possibility of intratemporal substitution.

Exploiting these advantages, our point estimate of the IES is 0.21, which is significantly less than 1 but not significantly different from 0. While the baseline regression uses the sample period between April 1992 and March 2002, the choice of sample period has little impact on our results. In addition, the results are robust to sample selection criteria. Point estimates from those robustness checks range between 0.17 and 0.36, comparable to those in previous studies using macrodata such as Hall (1988), Ogaki and Reinhart (1998), and Yogo (2004), but less than those using microdata such as Attanasio and Weber (1993, 1995), Vissing-Jorgensen (2002), and Gruber (2013). We employ additional tests to check whether liquidity constraints or data quality is responsible for the small IES but find no evidence to support these assertions.

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Our analysis also highlights the importance of allowing nonseparable preferences over durables and nondurables and suggests the two composite goods are strong complements. When we restrict preferences over durables and nondurables to be separable, we obtain a point estimate of the IES of 0.91, which is significantly larger than our baseline estimate of 0.21 and similar to the estimates of Attanasio and Weber (1993, 1995) and Vissing-Jorgensen (2002), who also use microdata but restrict preferences to be separable over durables and nondurables. Combining our empirical results with the Euler equation derived from the baseline model, we can go beyond our finding that preferences over durables and nondurables are nonseparable and place an upper bound on the elasticity of substitution between durables and nondurables. Specifically, our results imply that the elasticity of substitution between durables and nondurables is less than our IES estimate of 0.21. Thus, durables and nondurables are strong complements.

To the extent that our finding of a small IES is applicable in other contexts, it suggests that policies that aim to dampen volatility in household consumption expenditure through changes in the real interest rate will not be effective. For the same reason, the deadweight loss from a preannounced increase in a VAT and the taxation of interest income is likely to be small.

The remainder of the paper is organized as follows. Section II provides background on Japan's April 1997 consumption tax rate increase and evidence for our assertion that the tax rate increase presents an ideal natural experiment to estimate the IES. Section III introduces a representative agent model of household consumption to make predictions about household consumption in the months following announcement of a Consumption Tax rate increase. We then present an empirical specification consistent with the model and discuss identification of the IES. The data used in estimation and our results are presented in section IV. Section V summarizes and discusses our results.

II.   The Consumption Tax Rate Increase: An Ideal Natural Experiment to Estimate the IES

A.   Japan's Consumption Tax and the April 1997 Rate Increase

Japan's Consumption Tax is a value-added tax (VAT). Unlike VAT in many other countries, the consumption tax has a single flat rate with a relatively small number of exemptions.[1] In addition, as documented by Ishi (2001), the Japanese government made it clear that it expected the burden of the Consumption Tax would be borne fully by consumers.[2] Accordingly, changes in consumer prices should be proportional to changes in the Consumption Tax rate. In other words, given a nominal interest rate, an increase in the Consumption Tax rate lowers the real interest rate through a proportional price increase across goods and services.

The Consumption Tax was introduced in 1989 at a rate of 3%, and it was increased to 5% in April 1997. The 1997 increase was originally proposed as a part of the Murayama tax reform, which passed through the Japanese Diet in late 1994.[3] Because the primary purpose of the reform was to continue the shift from direct to indirect taxation, the consumption tax rate increase was coupled with immediate cuts in income tax rates. In that sense, the tax increase was compensated.

Although the Murayama reform package set a target date of April 1997 for the Consumption Tax rate increase, it was unclear whether the increase would actually be implemented then. This is because the reform legislation also stated that the increase would be imposed only if the economy had sufficiently recovered from a prolonged recession (1991–1993) and subsequent years of feeble growth. Having judged the economy to have sufficiently recovered, the ruling Liberal Democratic Party (LDP) decided to raise the tax rate as scheduled. The bill to raise the Consumption Tax rate passed through the upper house on June 25, 1996, and the tax rate increase was scheduled to become effective on April 1, 1997.

Even after this passage, it was not clear that the Consumption Tax rate increase would be implemented in April, as it was the central issue in October 1996 elections to the lower house of the Diet, with the LDP promising to implement the tax rate increase as planned while the opposition promised to shelve it. The LDP narrowly won the election, and on December 26, 1996, the government submitted the fiscal year 1997 budget, finally deciding to increase the Consumption Tax rate to 5% on April 1, 1997.

B.   The Consumption Tax Rate Increase as a Natural Experiment

To estimate the IES, variation in the real interest rate, the price of current consumption relative to future consumption, is necessary. Because the real interest rate is defined as the nominal interest rate minus the inflation rate, a change in the inflation rate will induce the necessary variation. As a result, the April 1997 Consumption Tax rate

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[1] Exemptions include transfer or lease of land, transfer of securities, transfer of means of payment, interest on loans and insurance premiums, transfer of postal and revenue stamps, fees for government services, international postal money orders, foreign exchange, medical care under the medical insurance law, social welfare services specified by the social welfare services law, midwifery service, burial and crematory service, transfer or lease of goods for physically handicapped persons, tuition, entrance fees, facilities fees, examination fees of schools designated by the Articles of the School Education Law, transfer of school textbooks, and the lease of housing units.

[2] When the consumption tax was introduced in 1989, the government took several steps to ensure this outcome. First, the Special Council on the Transition was formed to promote enforcement of the tax across agencies. Second, the government carried out an extensive advertising campaign to allay the public's fear of price hikes and restrain overcharging by traders. A telephone service was also set up so consumers could report complaints about prices. Finally, the Economic Planning Agency increased the budget for the price monitoring system. The situation was nearly identical in 1997.

[3] For the political process, see Ishi (2001) and Takahashi (1999).

FIGURE 1.—PERCENTAGE CHANGE IN NONSTORABLE, NONDURABLE PRICES
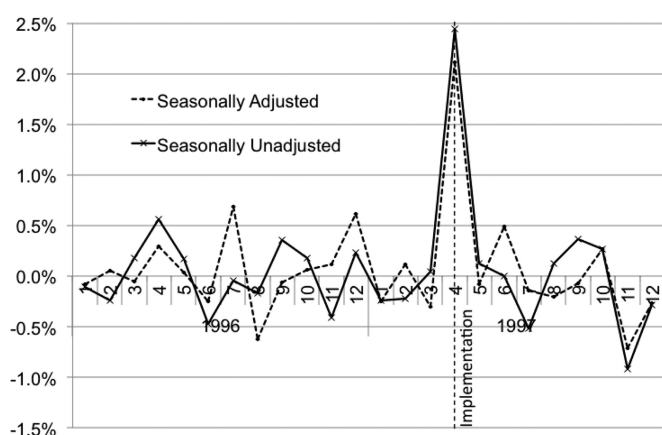
The figure presents the month-to-month percentage change in unadjusted and seasonally adjusted non-storable, nondurable prices. To remove seasonality, we regress the monthly percentage price change in nonstorable, nondurable goods and services on month dummies. The residuals are added to the constant term from the regression to obtain a seasonally adjusted monthly percentage price change. The dashed vertical line in the figure is April 1997, the month the consumption tax rate increase was implemented.

FIGURE 2.—AVERAGE INTEREST RATES ON SHORT-TERM LOANS AND DISCOUNTS

The figure presents the average contracted interest rate on short-term loans and discounts. These are the average interest rates applied to a contract of less than one year between commercial banks and lenders. The data come from the Bank of Japan.
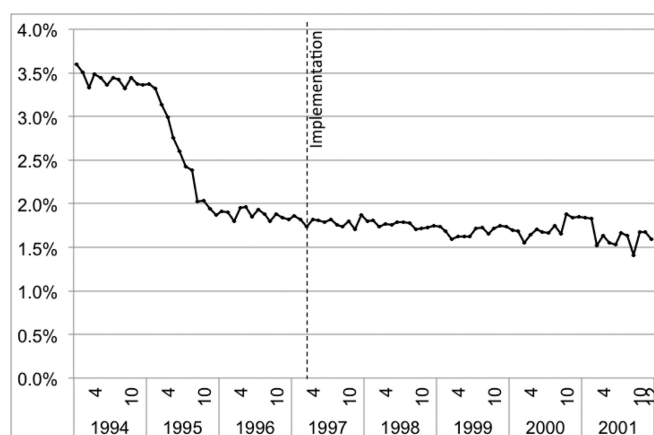
increase, which represented an exogenous increase in the future price level during a period in which nominal interest rates were stable, presents an ideal natural experiment to estimate the IES, which we discuss below.

First, the tax rate increase can be regarded as an exogenous change in consumer prices. Not only is it the case that the tax system is exogenous to individual households, but it is also true that the impact of the tax rate increase is independent of consumer behavior. This is because the VAT by and large applies to expenditures regardless of the characteristics of the consumer, the point of purchase, or the type of goods purchased. Figure 1 shows the month-to-month percentage change in the consumer price index for nonstorable, nondurable goods and services, the component of consumption expenditure that we use to estimate the IES. While inflation was negligible in most months prior to and following implementation of the tax rate increase, the price level increased by 2.39% between March and April 1997, consistent with full forward shifting of the Consumption Tax onto consumers at the time of implementation.[4] The figure also suggests that there was not a significant seasonal component to price changes around the time of the tax rate increase. Consequently, the optimal response to the Consumption Tax rate increase is unlikely to be confounded by seasonality in prices. As a result, we can focus on a one-time price change and rule out the influence of an additional factor (i.e., variation in pretax prices due to transitory or seasonal components) that affects the real interest rate.

We can also rule out the influence of the nominal interest rate on the real interest rate. Figure 2 presents the average contracted interest rates on short-term loans and discounts, which are the average interest rates applied to a contract of less than one year between a commercial bank and lender. The average interest rate fell precipitously throughout 1995

but remained relatively constant thereafter. This suggests that households would not change their nominal interest rate expectations in the months surrounding implementation of the Consumption Tax rate increase. In other words, households should not have expected any changes in nominal interest rates by the central bank that would offset or augment the intertemporal substitution incentives.

These facts imply that the tax rate increase can be regarded as an exogenous change in the real interest rate, which allows for consistent estimation of the intertemporal substitution response using ordinary least squares (OLS). Previous studies of intertemporal substitution have relied on an instrumental variables approach to address the well-documented endogeneity between the real interest rate and consumption growth. The standard approach has been to instrument for the contemporaneous real interest rate with lagged interest rates. However, there are several potential issues with the instruments that have been employed. First, as Yogo (2004) notes, it is notoriously difficult to predict the real interest rate, and therefore some of the previous studies in this literature (especially those using aggregate data) suffer from the weak instrument problem. Weak instruments lead to estimates of the IES biased in the direction of OLS, which itself is likely to suffer from a downward bias.[5] Even if the weak instrument problem is overcome, there still exists the potential for correlation between the lagged

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[4] Carroll et al. (2010) find that full forward shifting at the time of a consumption tax rate increase is the norm across most countries.

[5] Two-stage least squares (2SLS) estimators using weak instruments are biased in the direction of OLS for the following reason. Suppose the structural equation is given by $y_i = \beta x_i + \eta_i$ and the first-stage equation by $x_i = \pi z_i + \xi_i$. If π is truly 0 due to weak instruments, then any variation in the predicted value of x_i, $\hat{x}_i$ will come from ξ_i. It follows that the variation in $\hat{x}_i$ is no different from the variation in x_i, and the OLS and IV estimates are estimating the same quantity on average. For more information, see Pischke (2010).

Using OLS, Gruber (2013) obtains an estimate of the IES of -0.55, which is significantly less than his estimates when instrumenting for the after-tax real interest rate. Vissing-Jorgensen (2002) finds that estimates of the IES converge toward 0 as the number of instruments is increased. This is because the weak instrument problem is increasing in the degree of overidentification.

FIGURE 3.—NUMBER OF ARTICLES MENTIONING THE CONSUMPTION TAX
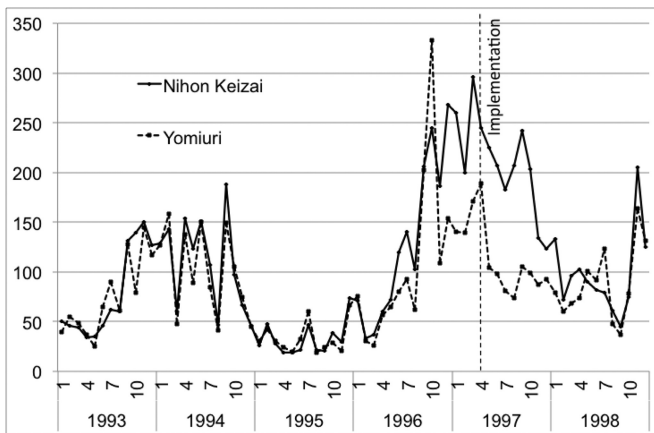
Source: Authors' calculations. Circulation numbers for the *Nihon Keizai Shimbun* and *Yomiuri Shimbun* are from Japan's Audit Bureau of Circulations.

FIGURE 4.—PRICE RATIOS RELATIVE TO NONSTORABLE NONDURABLES

The figure presents the ratio of seasonally adjusted durable and storable nondurable prices to nonstorable nondurable prices. To remove seasonality, we regress the consumer price indices for durable, storable nondurable, and nonstorable nondurable goods and services on month dummies. The residuals are added to the constant in the regression to obtain seasonally adjusted price indices. To calculate the ratios, we divide the seasonally adjusted durable and storable nondurable price by the seasonally adjusted nonstorable nondurable price in each month. The dashed vertical line in the figure is April 1997, the month of implementation.

interest rates and consumption growth, which is discussed by Gruber (2013). Furthermore, Attanasio and Weber (1993, 1995) show that studies using lagged instruments and aggregate nondurable expenditure data suffer from a downward bias in estimates of the IES known as aggregation bias.[6] This study avoids these issues by using an exogenous institutional price change.
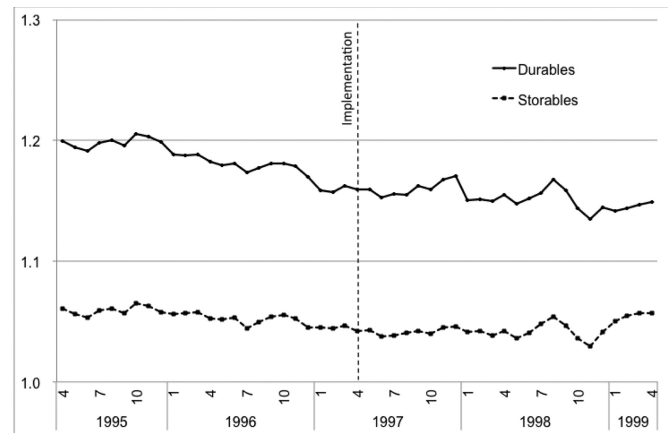
While exogenous variation in the real interest rate is a necessary condition for estimating the IES, it must also be the case that households are aware of the change. While we cannot provide direct evidence on household awareness of the consumption tax rate increase, we can provide indirect evidence by examining news coverage prior to implementation. Figure 3 reports the number of articles that mention the phrase *consumption tax* in the *Nihon Keizai Shimbun*, Japan's leading business newspaper, with a circulation of over 3 million (in 2010), and the *Yomiuri Shimbun*, a leading nonbusiness newspaper, with a circulation of over 10 million (in 2010).[7] There was a steady upward trend that began just prior to enactment of the June 1996 legislation. Coverage peaked in the *Yomiuri Shimbun* in October 1996, which coincided with elections to the lower house of the Diet. Overall coverage in both papers was consistently high in the months following the election but prior to the tax change, with nearly 300 articles in the *Nihon Keizai Shimbun* mentioning the consumption tax in March 1997. This suggests that households were aware of the tax rate increase and might therefore engage in intertemporal substitution behavior.

The news coverage also suggests that households may have been aware of the effects of the Murayama reform package as a whole. Figure 3 shows that coverage initially peaked in September 1994, which coincided with the passage of the Murayama reform. Accordingly, households may have known the package was intended to be revenue neutral over the long run. This in turn implies that the income effect associated with the tax rate increase would be small, and thus, we need not pay much attention to separate identification of the intertemporal substitution and income effects.[8]

Finally, the relative pretax price of goods and services did not change around the time of the consumption tax rate increase. Figure 4 shows the price of durables and storable nondurables relative to nonstorable nondurables around the time of the consumption tax rate increase. As the figure demonstrates, there was little change in the relative price of these goods. This fact allows us to make the simplifying assumption of constant relative pretax prices in the model presented in section III. As a result, we need only concern ourselves with the possibility of intratemporal substitution between durables and nonstorable nondurables resulting from the reduction in the user cost of durables just prior to the Consumption Tax rate increase, which we discuss further in Section IIIA.

To summarize, we argue that the April 1997 consumption tax rate increase presents an ideal natural experiment to estimate the IES for the following reasons: the tax rate increase can be regarded as an exogenous change in the real interest rate, the real interest rate was relatively stable prior to and following implementation, the tax rate increase was predictable and consumer awareness was high, and relative pretax prices were constant among taxable goods and services.

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[6] Attanasio and Weber (2010) sum up aggregation bias as follows: "The aggregate consumption growth rate is computed by taking logs of the mean of individual consumption, whereas [the log-linearized Euler equation] implies that means of the logs should be taken instead. . . . The difference between these two terms is highly serially correlated, thus invalidating lagged consumption growth as an instrument."

[7] Circulation numbers come from Japan's Audit Bureau of Circulations.

[8] That said, our empirical specification does attempt to identify the combined income and intertemporal substitution effects in the months immediately following announcement of the consumption tax rate increase.

III. A Consumption Tax Rate Increase and the Intertemporal Elasticity of Substitution

A. The Model

In this section, we construct a model to demonstrate the impact of a Consumption Tax rate increase on both household consumption and expenditure. A household consumes three types of taxable goods and services: nonstorable nondurables (N), storable nondurables (S), and durables (D).[9] Household i maximizes its lifetime utility function, U, the discounted sum of the instantaneous utility, u. Suppose the utility function at time s is

$$U_s = \sum_{t=s}^{\infty} \beta^{t-s} \left(\frac{\sigma}{\sigma - 1} \right) \left[u_t^{\frac{\sigma-1}{\sigma}} - 1 \right],$$

where β is the subjective discount factor, σ is the IES, and u_t is the instantaneous utility. Unlike previous studies, we use a deterministic setting because we focus on short-run dynamics around the time of the consumption tax rate increase.

Following Ogaki and Reinhart (1998), the intratemporal utility function is assumed to take the CES form for N, S, and D,

$$u_t = u\left(C_t^N, C_t^S, D_t \right) = \left[C_t^{N \frac{\epsilon-1}{\epsilon}} + a C_t^{S \frac{\epsilon-1}{\epsilon}} + b D_t^{\frac{\epsilon-1}{\epsilon}} \right]^{\frac{\epsilon}{\epsilon-1}},$$

where C_t^N and C_t^S are consumption of N and S, respectively; D_t is the stock of D held at the end of period t; ϵ is the intratemporal elasticity of substitution; and a and b are some positive numbers that determine the weights attached to S and D.[10] It is worth noting that the utility function becomes additively separable in N, S, and D if $\sigma = \epsilon$.

The CES specification assumes that preferences are homothetic. Pakos (2011) finds instead that preferences are nonhomothetic. Specifically, durables are luxuries and nondurables are necessities. If this is the case, ignoring nonhomotheticity can lead to an estimate of the IES that is biased upward (see also Okubo, 2008). Nevertheless, we believe it is reasonable to maintain the simplifying assumption of homotheticity, since income effects should not be present on implementation of the Consumption Tax rate increase.[11]

In maximizing its lifetime utility, the household faces three constraints: the intertemporal budget constraint and laws of motion for the stock of S and D. The intertemporal budget constraint is given by

$$A_t = (1 + i_t)A_{t-1} + Y_t - p_t^N C_t^N - p_t^S X_t^S$$
$$- p_t^D \left\{ X_t^D + \varphi\left(X_t^D \right) \right\} - \theta(S_t) \quad \text{for } t = s \cdots \infty,$$

where A_t is financial wealth held at the end of period t; i_t is the nominal interest rate in period t; Y_t is income; p_t^N, p_t^S, and p_t^D are the prices of N, S, and D, respectively; X_t^S and X_t^D are gross expenditures on S and D, respectively; and S_t is the stock of S held at the end of period t. The functions θ and φ represent costs associated with the storage of S and purchase of D, which we discuss below. Finally, we take A_{s-1}, D_{s-1}, and S_{s-1} as given.

As we discussed in the previous section, it was expected that the Consumption Tax rate increase would be fully passed onto consumers in the form of higher prices at the time of implementation (hereafter, period T). In addition, nominal interest rates and the pretax price level were stable around implementation. As a result, we can safely make the following two simplifications to the intertemporal budget constraint:

$$1. \begin{cases} p_t^N = p^N, \ p_t^S = p^S, \ p_t^D = p^D \\ \qquad \text{before and at period } T-1 \\ p_t^N = (1+\tau)p^N, \ p_t^S = (1+\tau)p^S, \ p_t^D = (1+\tau)p^D \\ \qquad \text{in and after period } T. \end{cases}$$

$$2. \ i_t = i \, \forall \, t,$$

where τ is the inflation rate due to the tax rate increase. In our case, $\tau = 0.0239$ because the CPI for N increased by 2.39% from March to April 1997.

The function θ accounts for the cost of holding a stock of storables, S.[12] This consists of costs from stock shortages as well as storage costs. For example, if a household runs out of storable nondurable goods such as toothpaste, there is a time cost associated with making a trip to the store to purchase an additional tube. Alternatively, stockpiling S requires the use of storage space that could be used for other purposes. These scenarios suggest that there exists a bliss point for the stock of S, S^*, which means that $\theta'(S_{i,t}) \leq 0$ if $S_{i,t} \leq S^*$ and $\theta'(S_{i,t}) > 0$ if $S_{i,t} > S^*$.

φ accounts for costs associated with the purchase of D. The purchase of a durable good is an infrequent event, and more effort is required than for a nondurable purchase. This may include collecting catalogs, identifying key specs, and shopping around to get a better price. Assuming that the

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[9] In online appendix A, we construct a model that allows nonseparable preferences over taxable and tax-exempt goods and services and derive testable implications regarding additive separability. The null hypothesis of additive separability is not rejected by the data. Based on this result, we ignore tax-exempt goods and services throughout our analysis.

[10] Because we are focusing on short-run dynamics, our model ignores the labor/leisure choice, effectively assuming that labor supply is fixed during the period of interest. This is made more plausible by the fact that we restrict our sample to households who do not change jobs during their time in the sample. Crossley, Low, and Wakefield (2009), who investigate a VAT rate change in the United Kingdom, also ignored the labor supply decision.

[11] Income effects associated with the Consumption Tax rate increase should appear on announcement of the tax rate increase, whereas identification of the IES relies on changes in expenditure on implementation of the Consumption Tax rate increase.

[12] Previous studies have shown empirically that demand is affected by the storability of a good (Hendel & Nevo, 2004, 2006). In particular, households weigh the benefits of purchasing storable goods at a lower price against the cost of holding additional inventory.

opportunity cost of a household's time spent shopping is increasing, convex, and proportional to the amount spent on durable goods, it follows that φ_i is increasing and convex in its argument, that is, $\varphi' > 0$ and $\varphi'' > 0$.

Finally, the evolution of the stocks of S and D is given by

$$S_t = (1 - \delta^s)S_{t-1} - C_t^S + X_t^S \text{ for } t = s \cdots \infty$$

and

$$D_t = (1 - \delta^D)D_{t-1} + X_t^D \text{ for } t = s \cdots \infty,$$

where δ^S and δ^D are the depreciation rates of S and D, respectively.[13]

B. Optimal Consumption Path and the Intertemporal Elasticity of Substitution

Solving the household's optimization problem, we obtain the following first-order conditions:

$$\frac{\partial U_t / \partial C_t^N}{\partial U_{t-1}/\partial C_{t-1}^N} = \left(\frac{F_t}{F_{t-1}}\right)^{\frac{\sigma-\in}{\sigma(\in-1)}} \left(\frac{C_t^N}{C_{t-1}^N}\right)^{\frac{-1}{\sigma}}$$

$$= \left(\frac{1}{\beta(1+i)}\right)\left(\frac{p_t^N}{p_{t-1}^N}\right), \qquad (1)$$

$$C_t^S = C_t^N \left(\left(\frac{1}{a}\right)\left(\frac{p^S}{p^N}\right)\right)^{-\in}, \qquad (2)$$

$$p_t^S + \theta'(S_t) = \frac{1 - \delta^S}{1 + i}, \qquad (3)$$

$$D_t = C_t^N \left(\frac{1}{b}\left(\frac{p^D}{p^N}\right)\right)\left[\left(1 + \varphi'(X_t^D)\right) \right.$$
$$\left. - \left(\frac{1-\delta^D}{1+i}\right)(1 + \Gamma_{t+1}\tau)\left(1 + \varphi'(X_{t+1}^D)\right)\right]\right)^{-\in}, \quad (4)$$

where

$$F_t = 1 + a\left(\frac{C_t^S}{C_t^N}\right)^{\frac{\in-1}{\in}} + b\left(\frac{D_t}{C_t^N}\right)^{\frac{\in-1}{\in}}$$

and

$$\Gamma_t = \begin{cases} 1 \text{ if } t = T \\ 0 \text{ if } t \neq T. \end{cases}$$

Equation (1) gives the standard Euler equation, which can be rewritten as

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[13] In the case that δ^S and δ^D are equal to 1, S and D effectively become nondurables.

$$\frac{C_t^N}{C_{t-1}^N} = [\beta(1+i)]^\sigma(1 + \Gamma_t\tau)^{-\sigma}\left(\frac{F_t}{F_{t-1}}\right)^{\frac{\sigma-\in}{\in-1}}.$$

Then, taking the logarithm of both sides and using the general approximation $\ln(1 + x) \cong x$ for small x, the consumption changes can be denoted as

$$\Delta\ln C_t^N = \kappa + \frac{\sigma-\in}{\in-1}\Delta\ln F_t - \sigma\Gamma_t\tau \qquad (5)$$

where $\Delta\ln C_t^N = \ln C_t^N - \ln C_{t-1}^N$ and $\Delta\ln F_t = \ln F_t - \ln F_{t-1}$.

This shows that once we assume that preferences over N, S, and D are additively separable (i.e., $\sigma = \in$), the IES, σ, can be estimated simply by dividing the change in log consumption growth of N at the time of implementation by the size of the tax rate increase, τ. However, as Ogaki and Reinhart (1998) point out, if preferences over N, S, and D are in fact nonseparable (i.e., $\sigma \neq \in$), this simple approach could yield a biased estimator. To address this issue, we add regressors to allow for nonseparable preferences in the empirical specification described below.

C. Empirical Specification

To estimate the IES, we use an empirical specification that is consistent with the model and is able to separately identify the IES from intratemporal substitution effects. According to the model presented above, the intratemporal substitution effects, or changes in $\ln F_t$, will appear symmetrically in the months prior to and following implementation. On the other hand, the intertemporal substitution effect is present only at the time of implementation. This is key to identifying the IES.

With this in mind, the following specification can identify the IES,

$$\Delta\ln C_{y,m}^N = controls + \sum_{(y,m)\in I} \alpha_{y,m}^N \Delta D_{y,m} + \gamma_{1997,\text{Apr}}D_{1997,\text{Apr}},$$

where $\Delta D_{y,m}$ is the first difference of month dummies for the period I and $D_{1997,\text{Apr}}$ is a dummy for April 1997.

Our main coefficient of interest is $\gamma_{1997,\text{Apr}}$, which corresponds to $-\sigma\tau$. Since τ is known to be 0.0239, as discussed above, the IES, σ, can be identified as $-\gamma_{1997,\text{Apr}}/\tau$. The $\alpha_{y,m}^N$'s correspond to $\frac{\sigma-\in}{\in-1}\Delta\ln F_{y,m}$, which capture the intratemporal substitution effects. Unless preferences are additively separable (i.e., $\sigma = \in$), at a minimum, $\alpha_{1997,\text{Mar}}^N$ should be nonzero and statistically significant, since the user cost of durables fell in this month. In more general cases where durable adjustment costs are present (i.e., $\varphi \neq 0$), $\alpha_{y,m}^N$ may be nonzero in other months surrounding implementation as well, since changes in F_t will be nonzero in months other than March 1997 (i.e., the set I may contain months in addition to March 1997).

TABLE 1.—BOUNDING ϵ USING ESTIMATES OF $\alpha_{1997,\text{Mar}}^N$ AND σ

		$\hat{\sigma}$	
		< 1	> 1
$\hat{\alpha}_{1997,\text{Mar}}^N$	> 0	$1 > \sigma > \epsilon$	$\sigma > \epsilon > 1$ or $\sigma > 1 > \epsilon$
	< 0	$1 > \epsilon > \sigma$ or $\epsilon > 1 > \sigma$	$\epsilon > \sigma > 1$

While our empirical specification can exactly identify the IES, the intratemporal elasticity of substitution, ϵ, is not directly identified. However, based on our model, bounds on the value of ϵ can be given. By the definition of F_t, we know that F_t is an increasing function of D_t/C_t^N if $\epsilon > 1$, and vice versa. In addition, $D_{1997,\text{Mar}}/C_{1997,\text{Mar}}^N$ should be greater than $D_{1997,\text{Feb}}/C_{1997,\text{Feb}}^N$ due to the lower user cost of durables in March. Thus, it follows that $\Delta \ln F_{1997,\text{Mar}} > 0$ if $\epsilon > 1$ and $\Delta \ln F_{1997,\text{Mar}} < 0$ if $\epsilon < 1$. On the other hand, it is mathematically obvious that the term $\frac{\sigma - \epsilon}{\epsilon - 1} > 0$ if $\sigma > \epsilon > 1$ or $\sigma < \epsilon < 1$ while $\frac{\sigma - \epsilon}{\epsilon - 1} < 0$ if $\epsilon < \sigma < 1$ or $\epsilon > 1 > \sigma$. Accordingly, once we estimate σ and $\alpha_{1997,\text{Mar}}^N$, we can place a bound on ϵ, as shown in table 1. To demonstrate, suppose we find that $\hat{\sigma} < 1$ and $\hat{\alpha}_{1997,\text{Mar}}^N > 0$ (the actual case we will find below); then we can conclude that $\epsilon < \sigma < 1$. Since $\alpha_{1997,\text{Mar}}^N$ corresponds to $\frac{\sigma - \epsilon}{\epsilon - 1} \Delta \ln F_{1997,\text{Mar}}$, it is positive when $\frac{\sigma - \epsilon}{\epsilon - 1} > 0$ and $\Delta \ln F_{1997,\text{Mar}} > 0$, or $\frac{\sigma - \epsilon}{\epsilon - 1} < 0$ and $\Delta \ln F_{1997,\text{Mar}} < 0$. Consequently, we know that either $\sigma > \epsilon > 1$ or $\epsilon < \sigma < 1$ should be satisfied. However, the former condition, $\sigma > \epsilon > 1$, cannot be satisfied with an estimate of σ less than 1; therefore, the theoretical upper bound of ϵ should be the estimated σ, $\hat{\sigma}$.

In addition to the dummies of interest, we add controls for factors affecting consumption that were excluded from the theoretical model, such as seasonality, demographics, and unobservables. The actual regression equation is

$$\Delta \ln C_{i,y,m}^N = c + \Delta Z_m \delta_m + \Delta X_{i,y,m} \phi +$$
$$+ \gamma_{1996,\text{Oct}} D_{1996,\text{Oct}} + \gamma_{1996,\text{Nov}} D_{1996,\text{Nov}}$$
$$+ \gamma_{1996,\text{Dec}} D_{\text{Dec}} + \gamma_{1997,\text{Apr}} D_{1997,\text{Apr}}$$
$$+ \sum_{(y,m) \in I} \alpha_i^N \Delta D_{y,m} + v_{i,y,m}^N, \quad (6)$$

where ΔZ_m is the first difference of a vector of month dummies. Consequently, δ_m represents the seasonal effects. $\Delta X_{i,y,m}$ is a vector of (potentially) time-varying household-specific characteristics, which includes the number of household members; the number of working household members; the number of household members under age 18; the number of household members above age 65; and interview dummies, which control for "survey fatigue," the tendency of households to report lower expenditure in later interviews. It is worth noting that household-specific fixed effects (or non-time-varying characteristics) are already controlled for by taking the first difference.

The dummies for October, November, and December 1996 ($D_{1996,\text{Oct}}$, $D_{1996,\text{Nov}}$, and $D_{1996,\text{Dec}}$, respectively) are included to determine whether there was any effect on consumption associated with announcement of the tax rate increase. The effect is the sum of the income effect and the intertemporal substitution effect. As we discussed in section II, the announcement of the tax rate increase occurred sometime between October and December 1996; thus, it is preferable to include not a single month but all three month dummies. The signs of the coefficients associated with each dummy are, however, ambiguous. The income effect should be negative because the rate increase represents a negative income shock, while the intertemporal substitution effect should be positive, reflecting households' incentive to increase their consumption during the periods between announcement and implementation, when the price level was relatively low. As a result, the sign of the coefficients depends on which effect dominated the other.[14]

Finally, $v_{i,y,m}^N$ is an error term that accounts for unobservables affecting household consumption of N. Standard errors are robust to serial correlation within households over time.

IV. Empirical Evidence

A. Data

We use data from the Japanese Family Income and Expenditure Survey (JFIES) to estimate the IES.[15] The JFIES is a rotating panel survey in which households are interviewed for six consecutive months and approximately 8,000 households are interviewed each month.[16]

Our estimates make use of JFIES data from the period between April 1992 and March 2002, a symmetric five-year window around the April 1997 rate increase. We choose to exclude the bubble years before April 1992 because household expenditures prior to 1992 grew at a much faster pace than they did after the bursting of the economic bubble in 1991; they remained more or less flat after that. Our sample period ends in March 2002, which coincided with the beginning of another boom.

We limit the sample to households that complete all six interviews, but nearly all households can be used as the response rate of the JFIES is quite high. Although data for agricultural households are available in the JFIES after

[14] There is also a literature that suggests that the income effect associated with a tax change is absent until the tax change is implemented. See, for example, Watanabe, Watanabe, and Watanabe (2001) and Mertens and Ravn (2012). If this were the case, our estimate of the IES would be biased upward, as the decline in expenditure from March to April would capture not only intertemporal substitution but also the negative income effect.

[15] See Stephens and Unayama (2011, 2012) for more information regarding the JFIES design and content.

[16] Until 2002, single-person and agricultural households were excluded from the JFIES. As of the 2009 JFIES, single-person households composed 11.8% of the population and were responsible for 18.1% of expenditures, while agricultural households accounted for 2% of the population and 2.1% of expenditures.

TABLE 2.—SUMMARY STATISTICS

Variable	Mean	SD	Minimum	Maximum
Age of head	51.5	13.7	17	99
Number of household members	3.38	1.24	2	11
Number of household members under age 15	0.68	0.98	0	7
Number of household members aged 65 or over	0.47	0.75	0	4
Number of working members	1.52	0.95	0	7
Yearly income	7,113	4,652	0	97,043
Total expenditure	317	266	20	14,346
Excluding tax-exempted items	221	195	15	9,255
Nonstorable nondurables (N)	120	78	7	5,523
Storable nondurables (S)	52	32	0.58	3,790
Durables (D)	47	138	0	7,678
Number of observations		646,900		
Number of households		129,380		

Yearly household income and monthly household expenditures are listed in thousands of yen, with 2005 serving as the base year.

1999, we drop them to maintain consistency over the sample period. Also, we use male-headed households and those whose head does not change his job because March is the end of the fiscal year in Japan, when we observe many job changes that may cause systematic changes in consumption around the time of the consumption tax rate increase. The sample restrictions leave us with 646,900 observations from 129,380 households. Table 2 presents summary statistics for our sample.

The JFIES expenditure data are highly disaggregated by item type, which allows us to accurately categorize goods and services. It is critical for our purpose to distinguish not only between taxable and tax-exempt goods and services but also between N, S, and D. To construct expenditure on N, we first exclude expenditures on goods and services that were not subject to the consumption tax. As shown in table 2, expenditure on taxed items was 70% of total expenditure, while most tax-exempt expenditure consists of rent for housing and education (e.g., tuition for school), which we would not expect to respond to a tax rate increase in the short run.

In the next step, we divide goods and services that were subject to the tax into three subcategories: D, S, and N. We define N as goods and services that are neither storable nor durable; that is, they depreciate relatively quickly over time when not in use, and when in use, they are fully consumed. As a result, this category contains goods and services for which the timing of consumption and expenditure roughly coincides. For example, fresh fruit, if not eaten, will spoil, and it is fully consumed with use. This category also includes services such as taxi service, which is consumed at the point of purchase.

We define S as those goods and services that depreciate slowly over time if not used and fully if used. It follows that these goods can be stockpiled for future consumption; consequently, consumption and expenditure do not necessarily coincide. For example, laundry detergent can be stored for long periods of time with little to no effect on its ability to clean clothing, but once it is put into use, whatever amount was used has been fully consumed. This category also

includes rail service, due to the fact that many Japanese households purchase passes that are good for train travel for several months. Thus, one might expect that a household would purchase a pass good for several months during a low-price period and use the pass during a relatively high-price period.

We define D as goods and services that depreciate relatively slowly over time if not used and do not depreciate fully with use. Consequently, consumption and expenditure do not coincide for durables. This category includes traditional durables such as refrigerators and automobiles, as well as goods such as clothing that are classified as semi-durables in the JFIES. In addition, we include a select group of services such as home repair and tailoring, from which consumers derive benefits long after the service is provided.[17]

We then deflate monthly expenditures on N, S, and D using tax-inclusive consumer price indices specific to our categories.[18] We are left with real monthly expenditures for Japanese households from April 1992 through March 2002. Table 2 shows that more than half of taxable expenditure is on N, while expenditures on S and D are similar. While it is known that D may be underreported in the JFIES, this is not the case for our dependent variable, N (see Unayama, 2011). Consequently, we are relatively unconcerned with selection issues for nondurable goods and services.

Figure 5 displays plots of unadjusted and seasonally adjusted real monthly household expenditure on N, S, and D in 1996 and 1997. Note that once expenditures on N are seasonally adjusted, as is the case in our empirical specification presented in section IIIC, there appears to be relatively little variation in N before and after implementation of the Consumption Tax increase, while expenditures on S and D exhibit a large spike in March 1997, followed by somewhat lower expenditure after the tax increase.

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[17] See table 2 in the online appendix for our complete categorization of N, S, and D.

[18] In particular, we construct Laspeyres price indices for each of our four categories using item-specific price indices and expenditure shares in 1990 for each of these items as the weights.

FIGURE 5.—JFIES AVERAGE MONTHLY HOUSEHOLD EXPENDITURE, 1996–1997
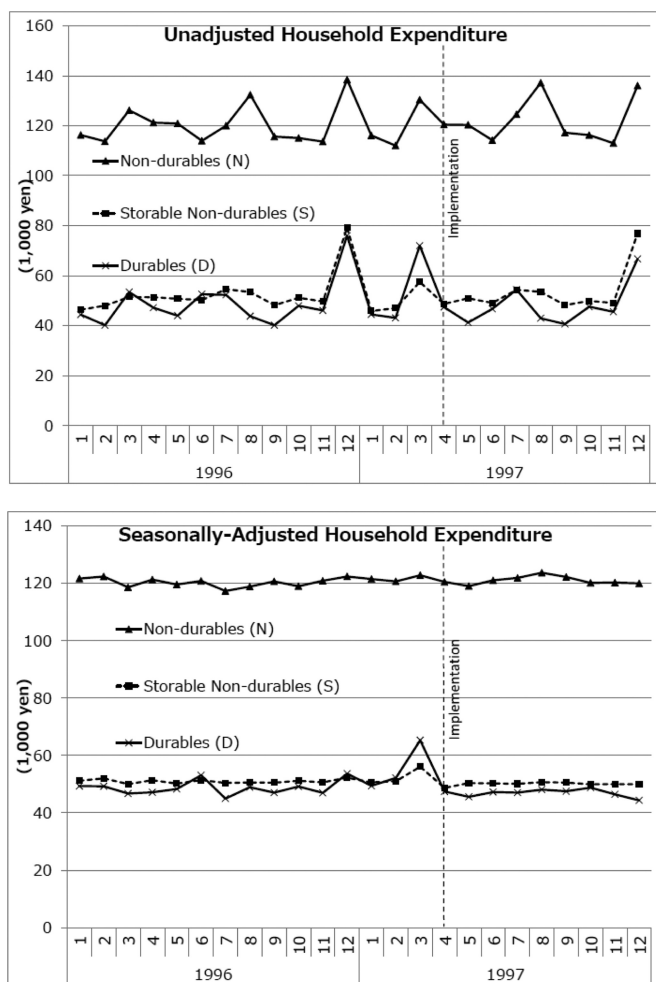
The figure displays plots of unadjusted and seasonally adjusted real monthly household expenditures (in thousands of yen) on nonstorable nondurable (N), storable nondurable (S), and durable goods and services in 1996 and 1997. The bottom figure, which displays seasonally adjusted household expenditures, plots the residuals plus the constant term from a regression of real monthly household expenditure on month dummies, where April serves as the base month. The dashed vertical line represents implementation of the consumption tax increase in April 1997.

B. Empirical Results

Table 3 presents our estimates for the entire sample based on the specification given in equation (6). Regression (1) includes only a dummy for April 1997. In effect, it ignores announcement and intratemporal substitution effects. We find that expenditure on N fell significantly between March and April 1997. The 2.16% decline in expenditure implies that the intertemporal elasticity of substitution is 0.91. The estimate of the IES remains unchanged in regression (2), which allows for announcement effects, but still these estimates ignore intratemporal substitution.

Regression (3), our baseline specification, adds a first-differenced March 1997 dummy intended to capture any intratemporal substitution that resulted from the fall in the user cost of durables in that month. Inclusion of this dummy reduces the coefficient associated with the April 1997 dummy from -2.16 to -0.51. The implied IES is 0.21, which is significantly less than 1 but not significantly

different from 0. The coefficient associated with the first-differenced March 1997 dummy, $\alpha^N_{1997,\text{Mar}}$, is positive and significantly different from 0.

Given our interpretation of $\alpha^N_{y,m}$ in section IIIC and IES (σ) estimate of 0.21, it follows that preferences over durables and nondurables are nonseparable and that the two composite goods are strong complements (i.e., $\epsilon < \sigma = 0.21$). Intuitively, this result is derived from the fact that the fall in the user cost of durables in March 1997 was accompanied by an increase in both durable and nondurable expenditures, while nondurable expenditures in other months prior to and following the tax rate increase exhibited little variation. The result is consistent with the findings of Pakos (2011) and Cashin (2016), but conflicts with the results of Ogaki and Reinhart (1998), who find an elasticity of substitution between durables and nondurables that exceeds 1.[19]

To develop a better sense of the strength of our complementarity result, we also examine the contemporaneous correlation between the first difference of the logarithm of monthly durable and nonstorable nondurable expenditures over our entire sample period. Figure 4 shows that the price of durables (relative to nondurables) fell throughout our sample period. Given this fact, a positive contemporaneous correlation would be consistent with complementarities. Indeed, we find a positive and highly significant contemporaneous correlation (0.10) between durable and nondurable expenditures, which further strengthens our finding that durables and nondurables are strong complements.[20]

To consider the possibility that the intratemporal substitution effects persisted beyond March and April 1997 as a result of durable adjustment costs, regression (4) of table 3 includes additional first-differenced month dummies. In this case, the estimate of the IES is slightly larger than in the baseline estimate (0.30), while we cannot reject the null that all first-differenced month dummies are 0.

Table 4 presents regression estimates intended to test the robustness of our results. Because seasonal effects may change over time, a longer sample period could yield an incorrect estimate of the IES. While we use the symmetric five-year window from 1992 through 2002 in the baseline, regression (1) uses a four-year window (1993–2001) and

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[19] Pakos (2011) demonstrates that Ogaki and Reinhart's result may be biased due to the assumption of homothetic preferences. Given homothetic preferences where durables are luxuries and nondurables are necessities, growth in the durable consumption share over time that has accompanied a fall in durable prices is incorrectly attributed to the substitution effect rather than the income effect.

[20] Another story, which is consistent with our result, but unrelated to complementarities between durables and nondurables, is that nondurables serve as an input to the durable purchase technology (e.g., consuming gasoline and eating out when purchasing a new television from an electronics store). Identification of the IES is robust to either story. The difference is the interpretation of the first-differenced March 1997 dummy. Under the complementarity story, the dummy captures complementarities between the service flow from the durable stock and nondurable consumption, while under the other story, it captures the additional nondurable purchases that must be made in order to facilitate the increase in durable purchases.

TABLE 3.—ESTIMATES OF THE INTERTEMPORAL ELASTICITY OF SUBSTITUTION (IES)
DEPENDENT VARIABLE: NONSTORABLE NONDURABLES ($\Delta \ln C_{i,y,m}^N \times 100$)

	(1)		(2)		(3)		(4)	
	Coefficient	SE	Coefficient	SE	Coefficient	SE	Coefficient	SE
First difference of month dummies								
$\Delta D_{\text{Feb,1997}}$							−1.10	0.78
$\Delta D_{\text{Mar,1997}}$					1.66**	0.82	0.56	0.91
$\Delta D_{\text{Apr,1997}}$							−0.89	0.94
$\Delta D_{\text{May,1997}}$							−1.54*	0.90
$\Delta D_{\text{Jun,1997}}$							0.06	0.78
p-value for F-test for all $\Delta D = 0$	NA		NA		0.042**		0.139	
Month dummies								
$D_{\text{Oct,1996}}$ (a)			−0.93	0.78	−0.93	0.78	−0.93	0.78
$D_{\text{Nov,1996}}$ (b)			1.21	0.76	1.21	0.76	1.21	0.76
$D_{\text{Dec,1996}}$ (c)			−0.05	0.79	−0.05	0.79	−0.05	0.79
$D_{\text{Apr,1997}}$ (d)	−2.16***	0.78	−2.16***	0.78	−0.51	0.84	−0.71	1.15
F-test: (a) + (b) + (c) = 0	NA		0.23		0.23		0.23	
(p-value)			(0.80)		(0.80)		(0.65)	
Implied IES (=|(d)| divided by 2.39)	0.91		0.91		0.21		0.30	
[95% CI]	[0.27, 1.55]		[0.27, 1.55]		[−0.48, 0.90]		[−0.65, 1.24]	
Sample period					1992–2002			
Sample restrictions					Yes			
Observations					646,900			

This table presents estimates from a regression based on equation (6). The dependent variable is the first difference of the logarithm of monthly household expenditures on nonstorable nondurable goods and services. Standard errors are robust to serial correlation within households over time. All columns report OLS regressions, which include, in addition to variables in the table, the first difference of month dummies, age of household head, and the first difference of the following variables: indicators for each interview, the number of household members, working members, members under age 18, and members over the age of 65. Significant at *10%, **5%, ***1%.

TABLE 4.—ROBUSTNESS TESTS: DIFFERENT SAMPLES

	Dependent Variable: Non-storable Non-durables ($\Delta \ln C_{i,y,m}^N \cdot 100$)					
	(1)		(2)		(3)	
	Coefficient	SE	Coefficient	SE	Coefficient	SE
First difference of month dummies						
$\Delta D_{\text{March,1997}}$	1.75**	0.83	1.54*	0.85	1.79**	0.74
Month dummies						
$D_{\text{Oct,1996}}$ (a)	−1.03	0.79	−0.38	0.81	−0.94	0.73
$D_{\text{Nov,1996}}$ (b)	1.60**	0.78	1.33*	0.79	1.60**	0.71
$D_{\text{Dec,1996}}$ (c)	0.03	0.80	0.13	0.82	0.10	0.72
$D_{\text{Apr,1997}}$ (d)	−0.41	0.86	−0.71	0.88	−0.86	0.78
F-test: (a) + (b) + (c) = 0	0.59		1.08		0.42	
(p-value)	(.407)		(0.266)		(.650)	
Implied IES (=|(d)| divided by 2.39)	0.17		0.30		0.36	
[95% CI]	[−0.53, 0.87]		[−0.43, 1.03]		[−0.27, 0.99]	
Sample period	1993–2001		1994–2000		1992–2002	
Sample restriction	Yes		Yes		No	
Observations	526,612		394,673		764,895	

This table presents estimates from a regression based on equation (6). The dependent variable is the first difference of the logarithm of monthly household expenditures on nonstorable nondurable goods and services. Standard errors are robust to serial correlation within households over time. All columns report OLS regressions, which include, in addition to variables in the table, the first difference of month dummies, age of household head, and the first difference of the following variables: indicators for each interview and the number of household members, working members, members under age 18, and members over the age of 65. Significant at *10%, **5%, ***1%.

regression (2) a three-year window (1994–2000). The resulting IES estimates (0.17 and 0.30, respectively) are similar to the baseline estimate. Regression (3) removes all sample selection criteria (e.g., male-headed household, participated in all six interviews). The implied IES is the largest of all our regressions (0.36), but still small and significantly less than 1.

Our results are comparable to the results in previous studies that use macrodata. Hall (1988) summarizes his results by saying that "the value may even be zero and is probably not above .2" (p. 350). Ogaki and Reinhart (1998) conclude that the point estimates fall in a "range of 0.32 to 0.45" when allowing for nonseparable preference (p. 1095);

moreover, Yogo (2004) reports the 95% confidence intervals [−0.56, 0.45] using Japanese data between 1970 and 1998 (Yogo, 2004, table 3).

In contrast, studies based on survey data have found larger estimates of the IES. Attanasio & Weber (2010) summarize their results (Attanasio & Weber, 1993, 1995) as follows: lower estimates of the IES based on macrodata can be explained by aggregation bias; once this bias is taken into account, the IES estimate increases to approximately 0.8 (Attanasio & Weber 2010). Similarly, Vissing-Jorgensen (2002) obtain point estimates of the IES in the range of 0.8 to 1.0 when accounting for limited asset market participation. Gruber (2013) obtains an even larger IES estimate of 2

TABLE 5.—HETEROGENEITY ACROSS HOUSEHOLD TYPES

	Dependent Variable: Nonstorable Nondurables ($\Delta \ln C_{i,y,m}^N \times 100$)							
	(1)		(2)		(3)		(4)	
	Coefficient	SE	Coefficient	SE	Coefficient	SE	Coefficient	SE
First difference of month dummies								
$\Delta D_{\text{Mar},1997}$	1.19	0.89	3.95**	2.00	1.48	1.11	1.70	1.21
Month dummies								
$D_{\text{Oct},1996}$ (a)	−0.82	0.85	−1.37	2.00	−1.88	1.10	0.25	1.09
$D_{\text{Nov},1996}$ (b)	0.99	0.81	2.28	2.22	1.18	1.06	1.28	1.10
$D_{\text{Dec},1996}$ (c)	−0.13	0.86	−0.27	2.05	0.39	1.10	−0.74	1.13
$D_{\text{Apr},1997}$ (d)	−0.57	0.93	−0.36	1.94	−0.36	1.17	−0.80	1.22
F-test: (a) + (b) + (c) = 0	0.04		0.36		0.23		0.23	
(p-value)	(0.97)		(0.62)		(0.81)		(0.55)	
Implied IES (=|(d)| divided by 2.39)	0.24		0.15		0.15		0.34	
[95% CI]	[−0.53, 1.01]		[−1.45, 1.75]		[−0.81, 1.11]		[−0.67, 1.34]	
Sample period	1992–2002		1992–2002		1992–2002		1992–2002	
Sample group	Working		No job		Higher income		Lower income	
Observations	539,073		107,827		311,837		335,063	

This table presents estimates from a regression based on equation (6). The dependent variable is the first difference of the logarithm of monthly household expenditures on nonstorable, nondurable goods and services. Standard errors are robust to serial correlation within households over time. All columns report OLS regressions, which include, in addition to variables in the table, the first difference of month dummies, age of household head, and the first difference of the following variables: indicators for each interview; the number of household members, working members, members under age 18, and members over the age of 65. Significant at *10%, **5%, ***1%.

when using cross-sectional variation in capital income tax rates as a source of identifying variation.

We believe that our estimates are preferable to previous estimates because we use microdata, a natural experiment approach, an appropriate categorization of nondurables, and a specification that is robust to nonseparable preferences between durables and nondurables. The use of microdata implies that our result is free from aggregation bias. Exploiting a natural experiment allows us to avoid the problem of weak instruments and the potential for correlation between lagged instruments and contemporaneous consumption growth.[21] Restricting the analysis to nonstorable nondurable goods and services mitigates the concern that we are capturing an expenditure elasticity rather than the intended consumption elasticity. Finally, as evidenced by the results from regressions (2) and (3) in table 3, allowing for nonseparable preferences has a significant impact on our estimate of the IES.

It is possible that our small estimate of the IES is attributable to liquidity constraints. Because liquidity-constrained consumers are less able to smooth consumption across periods, the estimated IES could be smaller if many households faced a binding constraint around the time of the consumption tax rate increase. To test for this possibility, we separate the sample into groups that are more likely to be liquidity constrained and groups that are relatively less likely to be constrained. First, we separate working and nonworking households. While the nonworking group includes unemployed households, most are retired.[22] Because retired households can expect little to no income growth, they are

much less likely to be liquidity constrained. As regressions (1) and (2) in table 5 show, the difference in the estimated IES between working and nonworking is small. A more conventional method to test for liquidity constraints is to divide households into higher- and lower-income groups. The results in regressions (3) and (4) indicate that the IES is slightly larger for lower-income households. Overall, the results in table 5 suggest that liquidity constraints are not responsible for our small IES estimate.

Data quality is another possible explanation why consumption of N was insensitive to the tax rate increase. If households incorrectly report their expenditures every month, the real changes would be attenuated by measurement error, causing our estimate of the IES to be biased toward 0. To evaluate this, we regress the first difference of the logarithms of S and (1 + D) on the same set of variables.[23] Expenditures on S and D should change around implementation much more than expenditure on N. This is because S and D are subject not only to intertemporal substitution in consumption, but also arbitrage effects. Regressions (2) and (3) in table 6, which employ the same specification used for N, given in equation (6), show that expenditures on S and D in March 1997 increased significantly. While it is difficult to interpret these coefficients, the results demonstrate that changes in expenditure are accurately reported, suggesting that data quality issues do not preclude us from finding a response to the Consumption Tax rate increase.

Finally, we consider the announcement effects. Specifically, we are interested in their sum. We find that the sum is slightly positive, but does not differ significantly from 0 in

[21] As in this paper, Engelhardt and Kumar (2009) use microdata and an approach that exploits a natural experiment to find the IES is 0.74. Unlike other papers (including this one), however, the IES is not derived from the Euler equation, and as a result, it is difficult to compare to our estimates.

[22] More than 90% of nonworking households are aged 60 or older.

[23] A small percentage of households report 0 monthly expenditure on durables, and as a result, we must take the logarithm of 1 + D. Results do not significantly change if we omit households with 0 durable expenditures from the analysis.

TABLE 6.—ARBITRAGE EFFECTS FOR STORABLES AND DURABLES

| | (1)[a] ((4) in Table 3) | | (2) | | (3) | |
| | Nonstorable Nondurables $(\Delta \ln C_{i,y,m}^N \times 100)$ | | Storable Nondurables $(\Delta \ln X_{i,y,m}^S \times 100)$ | | Durables $(\Delta \ln X_{i,y,m}^D \times 100)$ | |
	Coefficient	SE	Coefficient	SE	Coefficient	SE
First Difference of month dummies						
$\Delta D_{\text{Feb},1997}$	−1.10	0.78	0.01	0.87	7.16	3.40
$\Delta D_{\text{Mar},1997}$	0.56	0.91	10.06***	0.97	21.89***	3.71
$\Delta D_{\text{Apr},1997}$	−0.89	0.94	−3.80***	1.01	−0.35	3.72
$\Delta D_{\text{May},1997}$	−1.54*	0.90	−0.73	0.91	2.07	3.24
$\Delta D_{\text{Jun},1997}$	0.06	0.78	1.21	0.83	6.93**	2.94
p-value for F-test for all $\Delta D = 0$	0.139		0.00***		0.00***	
Month dummies						
$D_{\text{Oct},1996}$	−0.93	0.78	1.13	0.85	0.78	3.13
$D_{\text{Nov},1996}$	1.21	0.76	−1.91**	0.88	−4.02	2.95
$D_{\text{Dec},1996}$	−0.05	0.79	1.58*	0.94	3.41	3.03
$D_{\text{Apr},1997}$	−0.71	1.15	−2.43*	1.28	−8.13*	4.72
Sample period	1992–2002		1992–2002		1992–2002	
Sample restriction	Yes		Yes		Yes	
Observations	646,900		646,900		646,906	

This table presents estimates from a regression based on equation (6). The dependent variable is the first difference of the logarithm of monthly household expenditures on nonstorable nondurables (column 1), storable nondurables (column 2), and durables (column 3). Standard errors are robust to serial correlation within households over time. All columns report OLS regressions, which include, in addition to variables in the table, the first difference of month dummies, age of household head, and the first difference of the following variables: indicators for each interview; the number of household members, working members, members under age 18, and members over the age of 65. Significant at *10%, **5%, ***1%.

[a] This refers to column 4 in table 3.

all regressions presented in tables 3, 4, and 5. As discussed in section IIIC, this implies that the positive intertemporal substitution effect cancels out any negative income effect that may have resulted from announcement of the consumption tax rate increase.

V. Summary and Discussion

This study examines intertemporal substitution in consumption using a preannounced increase in Japan's consumption tax rate from 3% to 5%. Because the Japanese consumption tax is highly comprehensive, the tax rate increase was announced prior to its implementation, and other factors that affect the real interest rate were constant, it presents an ideal natural experiment to estimate the IES. A Japanese monthly household survey is exploited to accurately categorize nondurables. Our research design and the use of microdata allow us to avoid the problems of weak instruments and aggregation bias. Furthermore, our empirical specification is robust to intratemporal substitution between durables and nondurables. Given the exogenous change in the real interest rate, our detailed data, and flexible empirical specification, we find that the IES is small. The baseline point estimate is 0.21 and does not differ significantly from 0, but is significantly less than 1.[24]

From a broader policy standpoint, two implications emerge from our result. First, recent work by Correia et al. (2013) demonstrates that when nominal interest rates are at the zero lower bound, a reduction in the VAT can be used to mimic an interest rate cut. However, our result suggests that the stimulus provided by such a policy may be relatively limited.[25]

Second, previous authors (Kaplow, 2008; Auerbach & Kotlikoff, 1987; Auerbach, Kotlikoff, & Skinner, 1983) have raised concerns over the efficiency costs of preannounced increases in consumption tax rates. They posit that the longer the length of time between announcement and implementation of a consumption tax rate increase, the larger will be the welfare losses due to the acceleration of consumption in the period prior to implementation. However, our result suggests that the welfare losses of preannouncement are small.[26]

While we find that consumption is insensitive to the real interest rate, the same is not necessarily true for expenditure. Durability and storability allow households to change the timing of their expenditure without changing the timing of consumption. Our future work will examine these effects associated with Japan's consumption tax rate increase. In doing so, we will be able to fully characterize the consump-

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[24] The results of Pakos (2011) and Okubo (2008) suggest that our estimate of the IES would be even smaller had we allowed for nonhomothetic preferences.

[25] For a borrowing-constrained household, consumption should increase throughout the entire period of the rate decrease. Crossley et al. (2009) point out that the fraction of constrained households likely increases during downturns. If this is true, a rate decrease may provide stimulus not because of the intertemporal substitution effects but rather an income effect for constrained households.

[26] This finding is reinforced by the results in Cashin (2011), which examines the intertemporal substitution and arbitrage effects of three separate increases in the goods and services tax rate in New Zealand. In all three cases, the length of time between announcement and implementation differed, but in all three cases, the expenditure response was confined to the month prior to implementation, which indicates the response was driven by largely unavoidable arbitrage effects rather than intertemporal substitution in consumption.

tion and expenditure response to a change in the real interest rate.

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