Durable Goods and Consumer Behavior with Liquidity Constraints: Evidence from Norway

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Abstract

This paper jointly analyzes consumer demand and consumption for Norwegian consumers for 1979-2018 with allowance for durable goods and liquidity constraints. An indirect utility function is specified with the user cost of durable goods, and demand functions for nondurable and durable goods and a consumption Euler equation are estimated by incorporating liquidity constraints. Traditional demand analyses ignoring durable goods leads to a significant bias in the elasticities of nondurable goods. Norwegian consumers are found impatient with low risk aversion. There is weak evidence for liquidity constraints in consumption. No strong evidence exists for intertemporal substitution in consumption. A considerable effect of uncertainty is found on consumption, especially for durable goods.

Keywords: Indirect utility function, User cost of durable goods, Euler equation, Risk aversion, Intertemporal substitution.

JEL Classification: E21, D15, D12

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1. Introduction

The literature on consumer demand bounds with empirical studies undertaken to estimate price and income elasticities of goods and services, which are important summary measures characterizing consumer behavior (see Clemens et al., 2019, for a recent study covering 37 OECD countries). In these studies, durable goods are either ignored (Deaton and Muellbauer, 1980b), tacitly assuming that nondurable goods are separable from durable goods, or treated like nondurable goods without recognizing the inherent differences between the two classes of goods (see Clemens et al., 2019). Either approach is not satisfactory. Durable goods are essential in consumer behavior and play a pivotal role in the economy, and ignoring them may not provide an adequate portrayal of consumer behavior. Moreover, durable goods, unlike nondurable goods, have distinct features. The consumer does not derive utility directly from spending on durable goods in the current period, but rather from the flow of services they provide over time that is assumed to be proportional to the stock of these goods. This indicates that durable goods should be specified in a stock form, rather than as a quantity as is done in previous studies, in the consumer's optimization problem, with the user cost, not purchase price, as the relevant price that measures the opportunity cost of these goods.

In awareness of this problem, there is a growing body of empirical work in consumption analyzing nondurable consumption by incorporating durable goods with the user cost (see, e.g., Mankiw, 1985; Ogaki and Reinhard, 1998; Pakoš, 2011). These studies, however, employ restrictive utility functions to represent consumers' preferences, and are highly aggregated with no due regard to the components of nondurable consumption and leave unexplained the role of relative prices of nondurable goods in determining consumption. This can be justified under the assumption that consumers' preferences are homothetic in nondurable goods, which is found be inconsistent with observed consumer behavior (see Deaton and Muellbauer, 1980b).

It is, however, important to note that studies on consumer demand and consumption (including those with durable goods) are traditionally conducted in isolation of each other. Demand analysis is typically concerned with optimal allocation of consumption expenditure across goods *within periods*, and thus demand functions are estimated conditional on total expenditure, which is usually treated as exogenously given and left unexplained. However, to the extent that the consumer chooses consumption expenditure to optimally allocate wealth *across periods*, which is a focus in consumption analysis, consumption expenditure is not exogenously given but is endogenously determined in the consumer's optimization problem. This implies that the consumer's intratemporal (within period) and intertemporal (across period) allocation decisions cannot be separated; hence a proper understanding of consumer behavior entails an integration of consumer demand and consumption studies in a unifying framework.

To that end, we present and estimate an integrated model of consumer demand and consumption for Norwegian consumers by utilizing the idea of intertemporal two-stage budgeting with durable goods and liquidity constraints. There are studies on durable goods in consumption with liquidity constraints, but they fail to account for the intratemporal allocation problem of consumption (Chah et al., 1995; Alessie et al., 1997). There are also studies employing intertemporal two-stage budgeting, but they assume that capital markets are perfect and do not allow for durable goods (Blundell et al., 1997). Kim et al. (2021) generalize intertemporal two-stage budgeting but do not utilize the user cost of durable goods, and thus the demand for durable goods is not explicitly analyzed. Moreover, there are studies on consumer behavior for Norway that estimate demand functions as well as consumption functions; see the detailed literature review presented in the Appendix. However, virtually none of these studies incorporates durable goods, and they fail to allow for the interplay between the consumer's intratemporal and intertemporal allocation decisions. Thus they are limited in scope and analysis to address broad issues in consumer behavior in a unifying framework.

To represent consumer preferences in our analysis, we specify an indirect utility function as a function of total consumption on nondurable and durable goods and prices of these goods, with durable goods expressed in a stock form and their price represented by the user cost, and derive the demand functions for nondurable and durable goods. Then, from intertemporal optimization with the indirect utility function, we obtain the Euler equation for consumption with allowance for liquidity constraints. We generalize the traditional measure of risk aversion based on power or CRRA utility by utilizing the indirect utility function. Then by taking a lognormal approximation of the Euler equation, we derive a log-linearized consumption growth equation that depends on the interest rate, growth rates of nondurables prices and user cost, conditional variance capturing uncertainty with precautionary saving, and liquidity constraints.

We conduct an empirical analysis of the integrated model of consumer behavior, using annual Norwegian data for 1979-2018 on eight disaggregate nondurable goods and an aggregate durable good. We employ a flexible specification of the indirect utility function that places minimal restrictions on consumer preferences with a rank 3 demand system. We jointly estimate the system of nine budget share equations together with the Euler equation for consumption. Then we present new evidence on demand and intertemporal consumption relative to previous studies on Norwegian consumer behavior.

We find that traditional demand analyses ignoring durable goods lead to a significant bias in the elasticities of nondurable goods. Durable goods are largely found to be necessities and price-inelastic like most nondurable goods. Norwegian consumers are, in general, impatient with low risk aversion.There is weak evidence for liquidity constraints, which do not have an important influence on consumption. No strong evidence exists for intertemporal substitution in consumption of nondurable consumption and durable goods as well. However, there is a considerable effect of uncertainty found in nondurable as well as durable consumption. This suggests that increasing uncertainty causes consumersto reduce or defer current nondurable consumption and durables spending accompanied by an increase in precautionary savings, especially in times of economic weakness, as is observed during the current coronavirus pandemic.

2. Data and Preliminary Analysis

In this section, we discuss the construction of data used in our study and present a brief analysis of these data to motivate the formulation of the model in the next section. This is necessary because the requisite data are not readily available and, more importantly, because of the nature of durable goods, which are a main focus of our analysis.

2.1. Data

We use data, obtained from Eurostat online, on consumption expenditure of households in Norway for the period of 1979-2018. The data come from the “Economy and Finance” statistics (code “nama_10_co3_p3”), where household consumption is classified in terms of the COICOP (Classification Of Individual Consumption Purpose) 3-digit classification containing information on consumption expenditure in current prices (million Euros), percentage of total consumption, and the price index (2010 = 100), among others, for a range of European countries. See https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_10_co3_p3&lang=en

From Eurostat for Norway, we have constructed eight expenditure groups for nondurable goods and services and an aggregate durable good. Eight nondurable goods and services include (1) food and non-alcoholic beverages, (2) alcoholic beverages, tobacco and narcotics, (3) clothing and footwear, (4) housing services, (5) water and fuels, (6) health services, (7) transport services, (8) other nondurables and services. Durable goods include items such as furnishings, household equipment, appliances and equipment, vehicles, telephone and telefax equipment, and audio-visual, photographic and information processing equipment.

The aggregate price indexes for each category of nondurable goods and services and for an aggregate durable good are constructed as weighted averages of the component price indexes, with expenditure shares for each component good serving as weights. Then the quantity indexes for nondurable and durable goods are obtained by dividing their respective current expenditure by the associated price index, which equals real expenditure for nondurable and durable goods.

As argued in the Introduction, the relevant price of durable goods is the user cost r_t^k, not purchase price, of these goods. It is defined at time *t* as (see Deaton and Muellbauer, 1980a, Chapter 13)

$$r_t^k = p_t^k - \frac{(1-\delta)}{(1+r_{t+1})} p_{t+1}^k. \tag{1}$$

where p_t^k is the aggregate price of durable goods, δ is the depreciation rate assumed constant, and r_{t+1} is the interest rate at time *t*+1. Given a resale or second-hand market with no transaction cost, the user cost equals the net expense of buying a unit of durable goods in one period, using it in the same period and selling it at the discounted depreciated price in the next period. Assuming that p_t^k grows by $\Delta \ln p_{t+1}^k$ and approximating (1), the user cost of durable goods is considered its rental equivalent price, i.e., $r_t^k \approx p_t^k(r_{t+1} + \delta - \Delta \ln p_{t+1}^k)$, where $\Delta \ln p_{t+1}^k$ is the expected rate of inflation of durable goods. For the interest rate, a three-month interest rate on short-term government bonds is used. For the depreciation rate, we used δ = 0.20 (20% per year) (see Mankiew, 1985).

We assume that the consumer derives utility from the service flow of durable goods that is proportional to the stock of these goods. To construct durables stock, we utilize the following durables stock accumulation equation:

$$k_s = (1-\delta) k_{s-1} + q_s^k \text{ for all } s \geq t, \tag{2}$$

where k_s is the stock of durable goods at the end of time *s* and q_s^k is an aggregate quantity of durable goods at time *s*. To start the recursive process, we use the initial value of durables stock, k_o, calculated by utilizingthe formula: $k_o = q_o^k / (g+\delta)$, where q_0^k is real durables expenditure in the first year of the sample period, and *g* is the average geometric growth rate for the real durable expenditure in the sample (see Casselli and Feyrer, 2007, in the production context to construct capital stock).

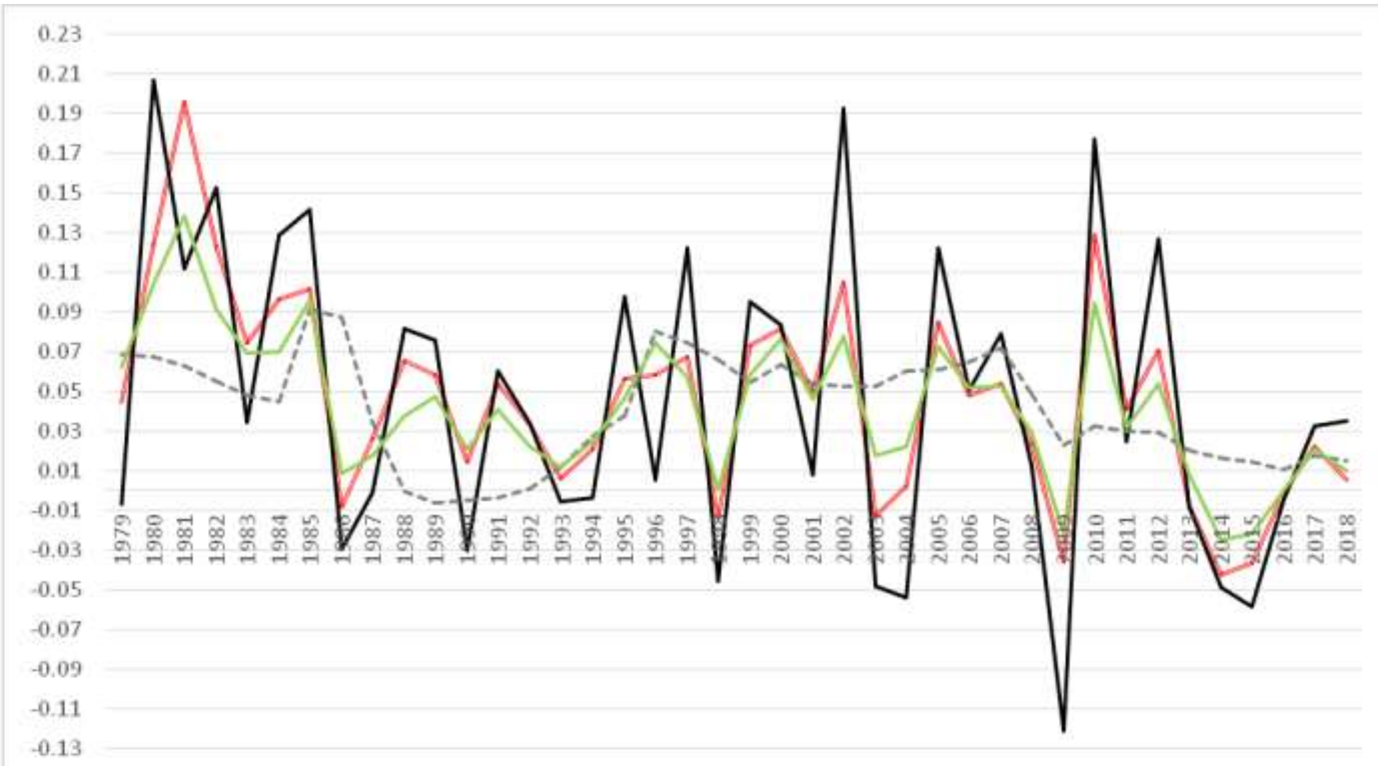
Given the user cost and durables stock, the relevant expenditure for durable goods is not their expenditure like nondurable goods but the value of durables services or the rental value of durables stock, i.e., $r_t^k k_t$. Then total consumption expenditure M_t is the sum of nominal expenditure on nondurables and services C_t and nominal expenditure on durables stock, $r_t^k k_t$, i.e., $M_t = C_t + r_t^k k_t$. We consider disposable income in our analysis. Expenditure and disposable income are expressed in per capita terms. Total real consumption expenditure is total current consumption expenditure divided by its price index.

2.2. Preliminary Analysis

Nondurable expenditure accounts for about 79%, and durables stock expenditure for about 21% of total consumption expenditure in Norway. Figure 1 shows the time series plots of annual percentage changes in nominal and real nondurable expenditures, as well as annual percentage change in durables stock and in total consumption. It is interesting to note that all series exhibit almost the same cyclical patterns. The nominal nondurable spending shows an average growth rate of 4.6% per year with the standard deviation of 5.1%, whereas the rate for durables stock is 4.6% per year with the standard deviation of 7.5%. Total expenditure exhibits an average growth rate of almost 4.6% per year with the standard deviation of 5.3%. The real growth rate of nondurable consumption shows an average rate of 2.8%, which is somewhat lower than that corresponding to the nominal rate of nondurable consumption. It is clear that during recessions, all series are falling.

Figure 2 displays the time series plots of the price indexes of nondurable and durable goods as well as the user cost of durables stock and the interest rate. The price index of nondurable goods has a stable upward trend over time, whereas the price index of durable goods shows a fluctuating pattern during the sample period. It was steadily rising with a peak occurring in 2002, followed by a steady fall until 2009, and then arise until 2012 followed by a fall until the end of the sample period. It is interesting to note that the user cost of durable goods shows an almost same pattern of the price index of durable goods, although with quite less fluctuations. The interest rate shows a slight decreasing trend over the years. It was above 10% during 1979-1992, but it has been falling since then – from the value of 7.265% in 1993 to 2.236% in 2012. It remained below 2% since then until the end of the sample period.

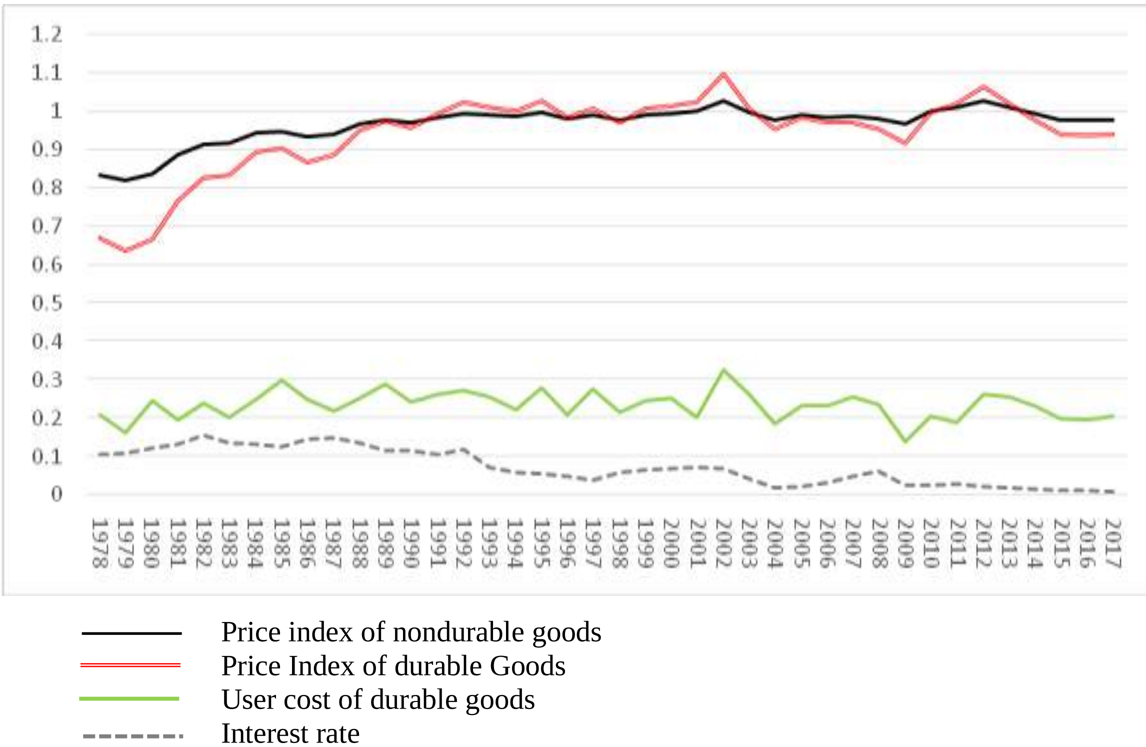
Figure 1: Annual Growth Rates of Consumption and Durables Stock



Nominal growth rate of M_t (total consumption)
Nominal growth rate of C_t (nondurable consumption)
Real growth rate of C_t (nondurable consumption)
Growth rate of k_t (durables stock)

For intertemporal analysis of consumption, we examine growth rates of nondurable consumption and durables stock as well as growth rates of associated prices and the interest rate (see Section 3.4 for a detailed discussion). Also important in this analysis is the role of uncertainty. While standard deviation or variance tells us about the variability of a variable, conditional variance is a relevant measure of uncertainty about the future (Ballie and Bollerslev, 1992). Conditional variances for total consumption, nondurable consumption, and durables

Figure 2: Movements of Price Indexes, User Cost, and Interest Rate over Time



stock growth are approximated by $\sigma^2_{M_{t+1}} = E_t\left[\left(\Delta \ln M_{t+1}\right)^2\right]$, $\sigma^2_{C_{t+1}} = E_t\left[\left(\Delta \ln C_{t+1}\right)^2\right]$, and $\sigma^2_{k_{t+1}} = E_t\left[\left(\Delta \ln k_{t+1}\right)^2\right]$, where E_t is the expectation operator conditional on information available at period *t.* They are also obtained by a second-order Taylor series expansion of an Euler equation with CRRA utility for M_t, C_t, and k_t (see Ludvigson and Paxson, 2001; Dynan, 1993) but are not directly observable. What we observe, instead, is the realized values $(\Delta \ln M_{t+1})^2$, $(\Delta \ln C_{t+1})^2$, and $(\Delta \ln k_{t+1})^2$. Under rational expectations, we can take the realized values by instrumenting them with lagged values. Gudmundsson and Natvik (2012) recognized the importance of uncertainty in consumption in Norway. They looked at three components of household consumption: nondurables, durables, and services to examine the effect of uncertainty on them. For durables consumption, its expenditure is used without considering the user costs. In contrast to our measures of uncertainty, they utilized two alternative measures of uncertainty – volatility indexes from financial markets and the frequency with which economic uncertainty is mentioned in the Norwegian press.

Table 1. Summary Statistics

Variable	Mean (%)	Std Dev	Minimum	Maximum
$\Delta \ln M$	4.61	7.82	-12.14	20.71
$\Delta \ln C$	4.74	5.13	-4.26	19.61
$\Delta \ln k$	4.17	2.73	-0.63	9.15
$\Delta \ln p_1$	2.56	5.19	-4.20	22.05
$\Delta \ln p_2$	4.65	6.46	-5.28	31.33
$\Delta \ln p_3$	-0.27	6.28	-17.65	17.56
$\Delta \ln p_4$	3.21	5.22	-6.39	17.60
$\Delta \ln p_5$	4.55	8.63	-11.07	22.50
$\Delta \ln p_6$	4.30	4.91	-4.25	16.12
$\Delta \ln p_7$	4.10	6.42	-10.21	23.39
$\Delta \ln p_8$	2.09	6.82	-9.53	19.83
$\Delta \ln r^k$	-0.05	22.79	-53.35	47.31
r	7.13	4.66	0.89	15.37
$\Delta \ln Y^d$	5.69	11.25	-22.11	35.97
σ_M^2	0.81	1.07	0.00	4.29
σ_c^2	0.48	0.71	0.00	3.85
σ_k^2	0.25	0.23	0.00	0.84

Notes: M = total expenditure, C = nondurable consumption, k = durables stock, p_1 = price of food and non-alcoholic beverages, p_2 = price of alcoholic beverages, tobacco and narcotics, p_3 = price of clothing and footwear, p_4 = price of housing services, p_5 = price of water and fuels, p_6 = price of health services, p_7 = price of transport services, p_8 = price of other nondurables and services, r = interest rate, r^k = user cost of durable goods, Y^d = disposable income, σ_M^2 = conditional variance of total expenditure measured by its realized value $(\Delta \ln M)^2$, σ_c^2 = conditional variance of nondurable consumption measured by its realized value $(\Delta \ln C)^2$, and σ_k^2 = conditional variance of durable goods measured by its realized value $(\Delta \ln k)^2$.

Table 1 contains the summary statistics for the relevant variables to be considered in the empirical analysis. Looking at growth rates of nondurable prices, goods experiencing high growth rates during the sample period are alcoholic beverages, tobacco and narcotics with 4.65%, followed by water and fuels (4.55%) and health services (4.33%). Clothing and footwear exhibit a negative growth rate of prices (-0.27%). Looking at standard deviations and minimum and maximum values of the variables, there is good evidence for the prevalence of intertemporal variations in the relevant variables. In particular, water and fuels had a highest standard deviation of 8.63, and clothing and footwear had a negative price growth rate but had a wide variation (6.28). The user cost of durable goods experienced a negative growth rate of 0.05%, but it has high standard deviation of 22.79. The interest rate during the sample period was 7% on average, but it has some variation. Regarding conditional variance, there is more uncertainty in nondurable consumption with more variability than in durables consumption. These results have an important implication for intertemporal analysis of consumption because the underlying assumption of this model is that intertemporal or temporary variations in prices and the interest rate trigger intertemporal variations in consumption (see Section 3.4).

3. The Model

3.1. Theoretical Framework

We consider a (representative) consumer who faces an optimal consumption problem of nondurable and durable goods over time and solves it in two stages in accordance with intertemporal two-stage budgeting. He chooses the level of consumption expenditure by optimally allocating wealth across periods in the first stage.[1] Then, in the second stage, each period's optimal allocation of consumption expenditure is distributed across nondurable and durable goods. The consumer, however, faces liquidity constraints because of limited opportunities to borrow against future labor income to finance current consumption expenditure. The solution to the above budgeting procedure can be found by reversing the order of the two stages: first, solve the second stage problem and then the first stage problem.

[1] We assume that durable goods are costlessly adjusted in a given period to facilitate the analysis. The use of annual data can provide a justification for such an assumption. Kim et al. (2021) also found an insignificant effect of adjustment costs for durable goods in consumption. Notably, this result is consistent with Hall (2004) who found relatively strong evidence against substantial adjustment costs for capital that has similar features of durable goods.

3.1.1. Indirect Utility Function and Demands for Nondurable and Durable Goods

Let $\mathbf{q}_t$ be an n quantity vector at period t of nondurable and durable goods, which consists of eight nondurable goods and an aggregate durable good by taking $q_{nt} \equiv k_t$. Given a direct utility function, $u(\mathbf{q}_t)$, which is continuous, increasing, and quasi-concave in $\mathbf{q}_t$, the consumer's second stage optimization problem is summarized by the indirect utility function, $v(M_t, \mathbf{p}_t)$, defined as

$$v(M_t, \mathbf{p}_t) \equiv \max_{\mathbf{q}_t}\{u(\mathbf{q}_t) \big| \mathbf{p}_t \cdot \mathbf{q}_t \leq M_t\}, \tag{3}$$

where M_t is consumption expenditure to be allocated among nondurable and durable goods at period t, i.e., $M_t = C_t + r_t^k k_t$, and $\mathbf{p}_t$ is an n price vector at period t of nondurable and durable goods with $p_{nt} \equiv r_t^k$. The above indirect utility function is well defined as a description of the consumer's within-period preferences under the following regularity conditions: it is continuous, increasing in M_t decreasing in $\mathbf{p}_t$,homogeneous of degree zero in M_t and $\mathbf{p}_t$, and quasi-convex in $\mathbf{p}_t$ (see Deaton and Muellbauer, 1980a).

Application Roy's identity to the indirect utility function (3) yields the system of nondurable and durable demand functions:

$$q_{it} = g_i(M_t, \mathbf{p}_t) = -\frac{\partial v(M_t, \mathbf{p}_t) / \partial p_{it}}{\partial v(M_t, \mathbf{p}_t) / \partial M_t}, \; i = 1, ..., n, \tag{4}$$

which consists of eight ordinary or Marshallian demand functions for nondurable goods and an aggregate ordinary demand function for durable goods. It should be noted that these demand functions for nondurable and durable goods are different from the traditional demand functions incorporating durable goods that are treated like nondurable goods (Clemens et al., 2019). In traditional demand analysis, the demand for durable goods is specified in a flow form, i.e., the quantity q_t^k of these goods, with the purchase price p_t^k. In our analysis, it is specified in a stock form, i.e., durables stock k_t with the user cost r_t^k. Further, in traditional demand analysis, durables expenditure is given by $p_t^k q_t^k$, and total expenditure M_t is defined as $M_t = C_t + p_t^k q_t^k$. In our analysis, durables expenditure is given by $r_t^k k_t$, and total expenditure is defined as $M_t = C_t + r_t^k k_t$. These results suggest that traditional demand analysis with durable goods likely leads to a bias in demand elasticities for nondurable and durable goods.

3.1.2. Intertemporal Optimization and the Consumption Euler Equation

The above second stage optimization problem is derived under the assumption that the consumer takes, as given, consumption expenditure M_t. The first stage problem of intertemporal two-stage budgeting allows us to determine it endogenously in the consumer's intertemporal optimization decision. In particular, the consumer faces an intertemporal finance or budget constraint:

$$A_s = (1+r_{s-1})A_{s-1} + Y_s - M_s \text{ for all } s \geq t, \tag{5}$$

where A_s is the value of financial assets at the end of period *s* to be carried into the next period, r_{s-1} is the nominal interest rate on assets that can be both bought and sold between periods *s*-1 and *s*,[2] Y_s is labor income at period *s*.[3] If the consumer faces a borrowing or liquidity constraint, debt cannot exceed the total current value of assets. The liquidity constraint is specified by

$$A_s \geq -L_s \text{ for all } s \geq t, \tag{6}$$

where L_s is the limit on net indebtedness at period *s* with $L_s \geq 0,$ for all $s \geq t.$[4] If $L_s = 0,$ the consumer cannot borrow or incur debt at all, but he can save and earn interest from his assets.

The direct and hence indirect utility function in (3) is ordinal; thus the *intratemporal* allocation of consumption across goods as captured by the demand functions (4) is invariant to a monotonic transformation of the utility function (3). However, the *intertemporal* allocation of consumption is invariant with respect to a linear transformation of the utility function, but not to other transformation of this function. For intertemporal preferences, we therefore take a Box-

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[2] It is common to specify the intertemporal budget constraint (5) with the interest rate r_s, the interest rate between periods *s* and *s*+1. To be consistent with the usual definition – and for easy interpretation – of the elasticity of intertemporal substitution (EIS), we instead specify it with r_{s-1} the interest rate between periods *s*-1 and *s* (see also Zeldes, 1989). This yields the Euler equation expressed with r_t [see equation (11)], which allows us to define the EIS with the interest rate measured at the current rate r_t (see Hall, 1988, and Section 3.1.4 for a detailed discussion) rather than at the future rate r_{t+1} as is done in most studies (see, e.g., Gourinchas and Parker, 2001; Havranek, 2015; Thimme, 2017).

[3] We consider leisure or labor supply as fixed and treat labor income as exogenous to the consumer's choice.

[4] We can treat L_s as a function of durables stock, meaning that durable goods can be used as collateral for borrowing (see Chah et al., 1995; Alessie et al., 1997). See also Section 3.2 for a related discussion.

Cox form for $v(M_t, \mathbf{p}_t)$:

$$U_t = \frac{v(M_t, \mathbf{p}_t)^{1-\zeta} - 1}{1-\zeta}, \tag{7}$$

where ζ is a Box-Cox parameter, with the marginal utility of M_t given by

$$U_M(M_t, \mathbf{p}_t) \equiv \frac{\partial U_t}{\partial M_t} = v(M_t, \mathbf{p}_t)^{-\zeta} v_M(M_t, \mathbf{p}_t), \tag{8}$$

where $v_M(M_t, \mathbf{p}_t) \equiv \partial v(M_t, \mathbf{p}_t)/\partial M_t$. The Box-Cox transformation with the parameter ζ allows the indirect utility function (3) to be cardinal under intertemporal separability of preferences. It also allows for an additional degree of flexibility in measuring the intertemporal properties of this function.While the indirect utility function (3) as a representation of within-period preferences is well defined with its regularity conditions discussed above, we assume that U_t in (7) is continuous, increasing, and, more importantly, strictly concave in M_t for given $\mathbf{p}_t$. The concavity condition ensures the existence of a solution to the intertemporal optimization problem, and implies that the necessary conditions are indeed sufficient.

Now, with the transformation of the indirect utility function, the consumer's first stage optimization problem is to choose M_s for $s \geq t$ so as to maximize

$$E_t\left[\sum_{s=t}^{\infty}(1+\rho)^{-(s-t)}\left(\frac{v(M_t, \mathbf{p}_t)^{1-\zeta} - 1}{1-\zeta}\right)\right], \tag{9}$$

where ρ is the constant rate of the consumer's time preference, subject to the intertemporal budget constraint (5), the liquidity constraint (6), and the appropriate transversality condition for assets. The expectation operator E_t is taken over future variables, using information available at the beginning of period *t*. We assume that the consumer replans continuously when solving the above stochastic dynamic control problem. This means that the calendar time τ solution for M_t should be the successive time *t* solution of this optimization problem as τ evolves through time, with the present always being time *t*. This idea satisfies dynamic consistency, in the sense that, provided expectations are realized, the optimal solution for M_s derived at time *t* will coincide with the time *t* solution derived beginning at time *s*. For estimation and data analysis then, only the first-order conditions necessary for the intertemporal optimization problem (6) at the initial point in time ($s = t$) are relevant. They are given by

$$M_t \;: v(M_t, \mathbf{p}_t)^{-\zeta} v_M(M_t, \mathbf{p}_t) = \lambda_t \tag{10}$$

and

$$A_t : \lambda_t - \phi_t = E_t\left[\left(\frac{1+r_t}{1+\rho}\right)\lambda_{t+1}\right], \tag{11}$$

where λ_t is the Lagrange multiplier associated with the asset accumulation constraint (5) known at time *t*, and ϕ_t is the Lagrange multiplier associated with the liquidity constraint (4) known at period *t*. ϕ_t will be positive when the liquidity constraint is binding and zero when it is not. Equation (10) indicates that the marginal utility of wealth is equated to the marginal utility of consumption at the optimum. This is a property implied by intertemporal separability of preferences that underlies intertemporal two-stage budgeting. Equation (11) is thestandard Euler equation for consumption adjusted for the presence of a liquidity constraint. For empirical analysis, it is convenient to work with this equation in a ratio form represented by

$$E_t\left[\left(\frac{1+r_t}{1+\rho}\right)\frac{\lambda_{t+1}}{\lambda_t}\right] = 1 - \hat{\phi}_t \;, \tag{12}$$

where $\hat{\phi}_t \equiv \phi_t / \lambda_t$.

3.1.3. Risk Aversion

The degree of relative risk aversion (*RRA*) is typically measured with the well-known power or CRRA utility function, $u(c_t) = \frac{c_t^{1-\zeta} - 1}{1-\zeta}$, with c_t real nondurable consumption, which gives *RRA* = ζ (see Hansen and Singleton, 1983; Mehra and Prescott, 1985). This measure of RRA hinges on restrictive preferences with real consumption under homothetic preferences, and its value is constant. To generalize the risk aversion measure based on power utility, we can employ the indirect utility function (3). However, while the demand functions are determined by an ordinary utility function, a risk aversion function is determined by a cardinal utility function. To allow for this, we take a Box-Cox transformation of the indirect utility function given in (7) with the marginal utility of consumption given in (8). The coefficient of relative risk aversion is then defined as

$$RRA(M_t, \mathbf{p}_t) = -\frac{M_t U_{MM}(M_t, \mathbf{p}_t)}{U_M(M_t, \mathbf{p}_t)} \equiv -\frac{\partial \ln U_M(M_t, \mathbf{p}_t)}{\partial \ln M_t}, \tag{13}$$

where

$$U_{MM}(M_t, \mathbf{p}_t) \equiv \frac{\partial U_M(M_t, \mathbf{p}_t)}{\partial M_t} = \frac{\nu_{MM}(M_t, \mathbf{p}_t)}{\nu(M_t, \mathbf{p}_t)^{\zeta}} - \zeta \frac{\left[\nu_M(M_t, \mathbf{p}_t)\right]^2}{\nu(M_t, \mathbf{p}_t)^{(\zeta+1)}}.$$

The concavity of the intertemporal utility function with respect to M_t implies that $U_{MM}(M_t, \mathbf{p}_t) < 0$ and hence $RRA(M_t, \mathbf{p}_t) \geq 0$.

3.1.4. Intertemporal Allocation of Consumption: Consumption Growth Equation

In the above discussion, consumption expenditure is treated as exogenous, but it is endogenously determined in the consumer's optimization problem. It is not, however, feasible to obtain a structural or closed form of this function from the intertemporal optimization problem, even for simple utility functions when the environment is stochastic. To circumvent this problem, it is instead a common practice to work with the Euler equation in studies on consumption and saving (see, e.g., Hall, 1978; Hansen and Singleton, 1983; Ludvigson and Paxson, 2001), which is adopted here. To do so, we use the Euler equation for consumption (12) and exploit a lognormal property. Assuming that the quantity $(\lambda_{t+1} / \lambda_t)$ has a lognormal distribution and takinglogs on both sides of (12), we have

$$\ln\left(\frac{1+r_t}{1+\rho}\right) + E_t(\Delta \ln \lambda_{t+1}) + \frac{1}{2}\mathrm{var}_t(\Delta \ln \lambda_{t+1}) = \ln(1-\hat{\phi}_t),$$

where $\Delta \ln \lambda_{t+1} \equiv \ln(\lambda_{t+1} / \lambda_t)$, the growth rate of the marginal utility of consumption. Rearranging this equation gives

$$\Delta \ln \lambda_{t+1} = -\ln\left[(1+r_t) / (1+\rho)\right] - (1/2)\sigma_{t+1}^2 + \ln(1-\hat{\phi}_t) + e_{t+1}, \tag{14}$$

where $\sigma_{t+1}^2 \equiv \mathrm{var}_t(\Delta \ln \lambda_{t+1})$ the conditional variance of marginal utility growth of consumption, and e_{t+1} is an expectation error at time t+1 that is uncorrelated with variables known at time *t*.

To evaluate (14), we need an expression for $\Delta \ln \lambda_{t+1}$. Logarithmically totally differentiating the marginal utility of consumption λ_t in (10), whose arguments are M_t and $\mathbf{p}_t$, with respect to time, and taking a discrete approximation of log changes, we obtain

$$\Delta \ln \lambda_{t+1} \approx b_{Mt} \Delta \ln M_{t+1} + \sum_{j=1}^{n} b_{jt} \Delta \ln p_{jt+1}, \tag{15}$$

where $b_{Mt} \equiv \frac{\partial \ln \lambda_t}{\partial \ln M_t} = -\zeta \frac{\partial \ln v(M_t, \mathbf{p}_t)}{\partial \ln M_t} + \frac{\partial \ln v_M (M_t, \mathbf{p}_t)}{\partial \ln M_t}$ and $b_{jt} \equiv \frac{\partial \ln \lambda_t}{\partial \ln p_{jt}} = -\zeta \frac{\partial \ln v(M_t, \mathbf{p}_t)}{\partial \ln p_{jt}} + \frac{\partial \ln v_M (M_t, \mathbf{p}_t)}{\partial \ln p_{jt}}$, j = 1 to n. Since the marginal utility of consumption is decreasing in M_t and p_{jt}, we expect that b_{Mt} and b_{jt} are negative. Substituting (15) into (14) and solving for $\Delta \ln M_{t+1}$, we obtain a log-linearized Euler equation for consumption growth:

$$\Delta \ln M_{t+1} = d_{rt} \ln\left[(1+r_t)/(1+\rho)\right] + \sum_{j=1}^{n} d_{jt} \Delta \ln p_{it+1} + d_{\sigma t}\sigma_{t+1}^2 + d_{\phi t} \ln(1-\hat{\phi}_t) + u_{t+1}, \tag{16}$$

where $d_{rt} \equiv -1/b_{Mt}, d_{jt} \equiv -b_{jt}/b_{Mt}, j = 1,...n,\ d_{\sigma_t} \equiv -1/(2b_{Mt}),\ d_{\phi t} \equiv 1/b_{Mt}$, and $u_{t+1} = e_{t+1} / b_{Mt}$.

Equation (16) identifies the variables governing the intertemporal allocation of consumption. The variables of focal interest are the time preference rate, the interest rate, liquidity constraints, and conditional variance. Ceteris paribus, a higher time preference rate implies a higher propensity to consume now rather than in the future with less saving, resulting in negative consumption growth. A change in the interest rate has the opposite effect of the time preference rate. In particular, the elasticity of intertemporal substitution (EIS) for consumption measures the response of expected consumption growth to changes in the current interest rate. In (16), the coefficient d_{rt} identities the EIS, that is, $d_{rt} = \partial \Delta \ln M_{t+1} / \partial \ln(1+r_t)$. Given the EIS, ceteris paribus, the relation between the time preference rate and the interest rate determines the growth of consumption, with the result that a high interest rate relative to the time preference rate increases consumption growth.

For any utility function separable over time and states, it is well known that the EIS equals the reciprocal of the coefficient of RRA, so RRA x EIS = 1. For power or CRRA utility, the EIS is given by 1/ζ. Given this property, it is easy to infer RRA from the estimated coefficient on the interest rate d_{rt} in the log-linearized consumption growth equation (16). Hall (1988), however, argues that this coefficient should be interpreted as the EIS and can only be informative about the degree of risk aversion under restrictive assumptions. This is the position we take in this paper by separately estimating RRA and EIS.

It is, however, worth noting that a change in the interest rate usually induces substitution as well as wealth effects on consumption. In evaluating these effects, it is important to distinguish between permanent and temporary changes in the interest rate because consumers react differently to these changes. When a change in the interest rate is *temporary*, i.e., a change in the *current* interest rate with all other future interest rates held constant, a mediate change in wealth is considered small enough to be ignored, thereby inducing an intertemporal substitution effect only (see Mankiw et al., 1985 in a different context). The intertemporal substitution effect will be especially strong when the change in the interest rate is temporary and fully anticipated. A *permanent* change in the interest rate, however, alters *current* as well as all *future* interest rates. A permanent change in the interest rate induces a non-trivial wealth effect but does not bring about an intertemporal substitution effect, because consumers adjust current as well as future consumption in the same direction in response to such a change in wealth. In general, a permanent change in the interest rate lasts for many periods, while a temporary change lasts for only short periods. In essence, a temporary change in the interest rate does not affect future interest rates and wealth, but a permanent change does. Hence, a temporary change in the interest rate effectively controls for the wealth effect, which allows us to properly identify the EIS. This has not received due attention in the literature on intertemporal substitution in consumption (Havranek, 2015; Thimme, 2017).

The variable $\widehat{\phi}$ in (16) refers to the degree of liquidity constraints. A binding constraint implies that $\widehat{\phi} > 0$. To see the effect of the liquidity constraint on consumption growth, the term ln(1-$\widehat{\phi}$) can be approximated by -$\widehat{\phi}$. Since $b_{Mt} < 0$ and thus $d_{\phi t} > 0$, this implies a positive relation between liquidity constraints and consumption growth. An increase in liquidity constraints means the consumer's ability to borrow is reduced, leading to a lower current consumption and thus increased consumption growth.

The variable σ_{t+1}^2 is conditional variance of consumption, which is a measure of uncertainty of consumption. The coefficient $d_{\sigma t}$ captures the effect of uncertainty on consumption. In the absence of insurance or risk sharing opportunities, uncertainty, in general, motivates consumers to engage in precautionary saving in the form of safe or liquid assets to guard against falling consumption or income in the future. This leads them to decrease current consumption in exchange for an increase in future consumption, resulting in higher expected consumption growth. Durables spending is particularly sensitive to uncertainty because purchase decisions are costly to reverse. In such a situation, uncertainty induces consumers to postpone these decisions rather than taking them immediately (see Gudmundsson and Natvik, 2012).

From the above discussions, it is clear that any change in the time preference rate, the interest rate, liquidity constraints, and uncertainty will have an effect on current consumption M_t and indirectly on the demands for nondurable and durable goods in (4). Commodity prices, which determine commodity demands, also influence consumption. This implies that the consumer's intratemporal and intertemporal allocations of consumption are inexplicably linked together. Hence, consumer demands and intertemporal consumption cannot be analyzed in isolation of each other, as is done in previous studies. Rather, a proper understanding of consumer behavior entails an integration of consumer demands and consumption with allowance for durable goods.

3.2. Empirical Specification

For empirical analysis, the specification of an appropriate functional form for the indirect utility function (3) is essential to obtain reasonable results. To properly characterize consumer behavior, however, the chosen functional form should be flexible while satisfying the requisite regularity conditions for within-period as well as intertemporal preferences. The PIGLOG (Price Independent Generalized Logarithmic) form, popularized by Deaton and Muellbauer's (1980b) Almost Ideal Demand System (AIDS) is widely used in demand analysis. Blundell et al. (1994), despite some drawbacks with this system, utilized it to analyze consumer behavior in the context of intertemporal two-stage budgeting with no durable goods. When there are substantial changes in real income or consumption, the implied budget share equations for AIDS violate the required monotonicity and curvature conditions. In this study, we have adapted Cooper and McLaren (1992)'s M(modified) PIGLOG form as a functional representation of the indirect utility function (3). This extended MPIGLOG form is a composite indirect utility function of rank 3 (McLaren and Wong, 2009) and thus is more flexible than PIGLOG and MPIGLOG forms based on rank 2. The MPIGLOG specification allows easier imposition of regularity conditions in the form of effective global regularity (Cooper and McLaren, 1996; McLaren and Wong, 2009).

With the extended MPIGLOG specification, the indirect utility function (3) is given by

$$\nu(M_t\ ,\ \mathbf{p}_t) = \left\{\frac{\left[\frac{M_t}{P_A(\mathbf{p}_t)}\right]^{\mu} - 1}{\mu}\right\} \frac{\frac{M_t^{\eta}}{P_B(\mathbf{p}_t)}}{1 + \frac{P_C(\mathbf{p}_t)}{M_t}}\ , \tag{17}$$

where μ and η are parameters with and $\mathrm{P}_A(\mathbf{p}_t)$, $\mathrm{P}_B(\mathbf{p}_t)$, and $\mathrm{P}_C(\mathbf{p}_t)$ are price indexes that are positive, increasing, and concave in $\mathbf{p}_t$. We assume that the price indexes take the forms:

$$\mathrm{P}_A(\mathbf{p}_t) \equiv \left(\sum_{j=1}^{n} \alpha_j p_{jt}^{\rho_A}\right)^{1/\tau_A}, \mathrm{P}_B(\mathbf{p}_t) = \prod_{j=1}^{n} p_j^{\beta_j}, \sum_{j=1}^{n} \beta_j = \eta, \text{ and } \mathrm{P}_C(\mathbf{p}_t) = \sum_{j=1}^{n} \gamma_j p_j. \quad (18)$$

Given (17) and (18), we can see the direct connections between the extended MPIGLOG - MPIGLOG forms and MPIGLOG - PIGLOG forms. If we set μ to be zero, equation (17) reduces to the MPIGLOG form (Cooper and McLaren, 1992). In addition, setting η to be zero, the MPIGLOG form reduces to the Deaton and Muelbauer's (1980b) PIGLOG form.

Given (17) together with associated price indexes in (18), we obtain the following derivatives:

$$\frac{\partial v(M_t, \mathbf{p}_t)}{\partial M_t} = \left[\frac{\frac{M_t^{\eta}}{P_B(\mathbf{p}_t)}}{M_t + P_C(\mathbf{p}_t)}\right]\left[1 + \left(\mu + \eta + RP_{C_s}\right)R_t\right], \quad (19)$$

$$\frac{\partial v(M_t, \mathbf{p}_t)}{\partial p_{it}} = -\left[\frac{\frac{M_t^{\eta-1}}{P_B(\mathbf{p}_t)}}{M_t + P_C(\mathbf{p}_t)}\right]\left[\frac{(1+\mu R_t)E_{Ait} + \beta_i R_t}{p_{it}} + \frac{\gamma_i R_t}{M_t + P_C(\mathbf{p}_t)}\right], i = 1, ..., n, \quad (20)$$

and

$$\frac{\partial^2 v(M_t, \mathbf{p}_t)}{\partial M_t^2} = \left\{\begin{matrix}\left(\mu + \eta + RP_{C_t}\right)(1+\mu R_t) - RP_{C_t}\left(1 - RP_{C_t}\right)R_t \\ + \left[\eta - \left(1 - RP_{C_t}\right)\right]\left[1 + \left(\mu + \eta + RP_{C_t}\right)R_t\right]\end{matrix}\right\} \times \left[\frac{\frac{M_t^{\eta-1}}{P_B(\mathbf{p}_t)}}{M_t + P_C(\mathbf{p}_t)}\right], \quad (21)$$

where $R_t = \frac{\left[\frac{M_t}{P_A(\mathbf{p}_t)}\right]^{\mu} - 1}{\mu}$, $RP_{C_t} = \frac{P_C(\mathbf{p}_t)}{M_t + P_C(\mathbf{p}_t)}$, and $E_{Ait} = \frac{\partial \ln(P_A)}{\partial \ln(p_{it})} = \frac{\alpha_i p_{it}^{\tau_A}}{\sum_j \alpha_j p_{jt}^{\tau_A}}$.

Expressions (19) and (20) could be used to derive the demand functions for food via Roy's identity (4). In a budget or expenditure share form, we have

$$S_{it} = -\left(\frac{\partial v(M_t, \mathbf{p}_t)/\partial p_{it}}{\partial v(M_t, \mathbf{p}_t)/\partial M_t}\right)\frac{p_{it}}{M_t} = \frac{(1+\mu R_t)E_{Ait} + +\beta_i R_t + \frac{\gamma_i p_{it} R_t}{M_t + P_C(\mathbf{p}_t)}}{1 + \left(\mu + \eta + RP_{C_t}\right)R_t}, \ i = 1, ..., n, \quad (22)$$

where $S_{it} \equiv p_{it} q_{it} / M_t$ is the share of the ith $(i = 1, ..., n)$ good in total expenditure, with $\sum_{i=1}^{n} S_{it} = 1$. The coefficient of relative risk aversion (13) is derived as

$$RRA(M_t, \mathbf{p}_t) = \xi \frac{\partial \ln \nu(M_t, \mathbf{p}_t)}{\partial \ln M_t} + \frac{\partial \ln \nu_M(M_t, \mathbf{p}_t)}{\partial \ln M_t}, \quad (23)$$

where

$$\frac{\partial \ln \nu(M_t\ ,\ \mathbf{p}_t)}{\partial \ln M_t} = \frac{1}{R_t} + \left(\mu + \eta + RP_{C_t}\right)$$

and

$$\frac{\partial \ln \nu_M(M_t\ ,\ \mathbf{p}_t)_t}{\partial \ln M_t} = \frac{\left(\mu + \eta + RP_{C_t}\right)\left(1 + \mu R_t\right) - RP_{C_t}\left(1 - RP_{C_t}\right)R_t}{1 + \left(\mu + \eta + RP_{C_t}\right)R_t} + \eta - \left(1 - RP_{C_t}\right).$$

The Euler equation in (12) could be written as

$$\frac{(1 + r_t)}{(1 + \rho)}\frac{\lambda_{t+1}}{\lambda_t} + \frac{\Phi_t}{\lambda_t} = 1 + \varepsilon_{t+1}\ , \qquad (24)$$

where $\lambda_{t+s} = \frac{\nu(M_{t+s}, \mathbf{p}_{t+s})^{-\xi}}{1 + \rho^s}\frac{\partial \nu(M_{t+s}, \mathbf{p}_{t+s})}{\partial M_{t+s}}$, for s = 0 and 1, and ε_t is an expectation error, with $\nu(M_{t+s}, \mathbf{p}_{t+s})$ and $\frac{\partial \nu(M_{t+s}, \mathbf{p}_{t+s})}{\partial M_{t+s}}$ given by (17) and (19). Estimation of the Euler equation (24) requires the solution for the Lagrange multiplier or shadow price for liquidity constraints ϕ_t. This variable is a non-differentiable function of many variables, which is difficult to derive analytically. As a result, previous studies often employ some indicators such as wealth to identify whether households are liquidity constrained (see Zeldes, 1989; Wakabayashi and Horioka, 2005). In this paper, we use a different approach to identify the presence or absence of liquidity constraints. When the consumer faces a liquidity constraint, his ability to adjust current consumption is limited in response to a future increase in income; hence his optimal consumption is constrained by current income. If the consumer is liquidity-constrained and his disposable income increases in the current period, the constraint will be relaxed and therefore ϕ_t will fall, suggesting a negative relation between ϕ_t and disposable income (Zeldes, 1989). Moreover, owing to their unit value and longer lifetime, some durable goods can be used as collateral, which makes consumers easier to finance using credit (Chah et al., 1995; Alessie et al., 1997). We can then expect a negative relation between ϕ_t and durables stock. We therefore use disposable income and durables stock as measures of liquidity constraints, and express ϕ_t as a function of these variables; that is,

$$\phi_t = \phi_0 + \phi_1 \ln Y_t^d + \phi_2 \ln k_t \,, \tag{25}$$

where Y_t^d is disposable income at period *t*, and ϕ_1 and ϕ_2 are parameters with the restriction that $\phi_1 < 0$ and $\phi_2 < 0$ if the consumer is liquidity constrained.

Further properties of the extended MPIGLOG budget share system (22) can be derived. The expenditure elasticities satisfy

$$\frac{\partial \ln g_i(M_t\,,\,\mathbf{p}_t)}{\partial \ln M_t} = 1 + \frac{1}{Z_{it}}\left[\left[\mu E_{Ait} + \beta_i + \frac{\gamma_i p_{it}}{M_t + P_C(\mathbf{p}_t)}\right]\left[\frac{M_t}{P_A(\mathbf{p}_t)}\right]^{\mu} - \frac{\gamma_i p_{it} R_t (1 - RP_{C_t})}{M_t + P_C(\mathbf{p}_t)}\right]$$

$$- \frac{1}{Z_{M_t}}\left[\left(\mu + \eta + RP_{C_t}\right)\left[\frac{M_t}{P_A(\mathbf{p}_t)}\right]^{\mu} - RP_{C_t}\left(1 - RP_{C_t}\right)R_t\right], \tag{26}$$

and the own/cross price elasticity equations satisfy

$$\frac{\partial \ln g_t(M_t\,,\,\mathbf{p}_t)}{\partial \ln p_{jt}} = -\delta_{ij} + \frac{1}{Z_{it}}\left\{\begin{aligned}&\left(1+\mu R_t\right)\left[E_{Aijt} - E_{Ajt}\left(\mu E_{Ait} + \beta_{it} + \frac{\gamma_i p_{it}}{M_t + P_C}\right)\right] + \beta_{it} R_t \\ &+\left(\frac{\gamma_i p_{it} R_t}{M_t + P_C}\right)\left[\delta_{ij} - \left(\frac{\gamma_i p_{jt}}{M_t + P_C}\right)\right]\end{aligned}\right\}$$

$$- \frac{1}{Z_{M_t}}\left[-\left(1+\mu R_t\right)E_{Ajt}\left(\mu + \eta + RP_{C_t}\right) + \left(\frac{\gamma_j p_{jt} R_t}{M_t + P_C}\right)\left(1 - RP_{C_t}\right)\right], \; i, j = 1, \ldots, n, \tag{27}$$

where Z_{it} and Z_{M_t} are the expressions in the top and bottom of equation (22), and δ_{ij} is the Kronecker delta.

4. Estimation and Results

Empirical investigation was carried out using annual consumption expenditure data for Norway discussed in Section on eight nondurable goods and an aggregate durable good spanning the period 1979 to 2018. In this section, we discuss estimation procedures of the empirical model and present estimation results.

4.1. Estimation methods

To obtain the values of parameters in the extended MPIGLOG indirect utility function (17) together with the Box-Cox parameter ξ and the time preference rate ρ appearing in the intertemporal optimization problem (9), we jointly estimate the budget share equations for eight nondurable goods and an aggregate durable good in (22) and the Euler equation for total consumption in (24). Although the Euler equation contains all information to identify the parameters, its use only is not efficient because it neglects the information given in the budget share equations. In estimation, it should be noted that total consumption M_t is not exogenous but endogenously determined in the consumer's optimization problem and hence is correlated with the error terms. Also, current prices $\mathbf{p}_t$ and the interest rate r_t may not be strictly exogenous. Moreover, there are variables dated *t*+1 that need to be properly treated in estimation. The use of the realized values causes them to be correlated with the error terms. These facts suggest an instrumental variables approach, particularly the Generalized Method of Moments (GMM), to estimate the model because the Euler equation, which states that the expectation at time *t* of a function of variables at times *t* and *t*+1 is zero, provide moment conditions (Hansen and Singleton, 1982). Under rational expectations, an expectation error is orthogonal to any information available to the consumer at time *t*.

Invoking rational expectations to the budget share equations is, however, only appropriate when these equations hold without error or are non-stochastic. In practice, these equations also contain errors arising from optimization or taste shocks. These errors are likely to be correlated with variables in the budget share equations and the Euler equations as well. Also, serial correlation is a common issue in estimation of the budget share equations. This implies that the Euler equation and the budget share equations hold in expectation under weaker conditions than the rational expectations model suggests. In estimation, we have experienced some identification problems with GMM and thus deploy nonlinear three stage least squares (3SLS) to estimate the system of budget share equations (22) and the Euler equation (24), using as instruments a set of variables that does not include any current variables appearing in the equation system.[5] To accommodate evidence of significant positive serial correlation in the budget share equations revealed in initial estimation, we use Moschini and Moro (1994)'s correction for autoregressive errors.

To estimate the consumption growth equation in (16), we assume that all explanatory

[5] Mankiw et al. (1985) also utilized 3SLS by using the similar argument to estimate the Euler equations for consumption and labor supply.

variables may not be strictly exogenous. Hence, we pursue an instrumental variables method, using as instruments one-period lags of all regressors. For conditional variance of total consumption, we can take the realized values by instrumenting them with lagged values under rational expectations (see the discussion in Section 2.2). We also assume that other explanatory variables such as the interest rate and growth variables may not be strictly exogenous and thus instrument them with lagged values.

4.2. Parameter Estimates

Table 2 reports estimation results for the empirical model based on joint estimation of the nine budget share along with the Euler equation for consumption. The following comments are in order. The model is highly nonlinear with many parameters, and we experienced a convergence problem. Thus to ensure that the requisite within-period and intertemporal regularity conditions are satisfied, we imposed a parameter restriction in estimation by setting $\gamma_3 = 0$ in the extended MPIGLOG indirect utility function (17). With this restriction, all of the regularity conditions are satisfied at every sample period. The χ^2 based J-test shows that the overidentifying restrictions are not decisively rejected at the conventional significance levels, providing evidence for the validity of the chosen instruments in our estimation. Moreover, the general fit of the budget share system as indicated by the R^2 values is quite good.[6] Autocorrelation diagnostics revealed in the Durbin-Watson and Box-Pierce χ^2 statistics suggest that serial correlation in the error terms is no longer severely pathological.

While these results lend some validity of our estimated model, there are some estimated parameters that are of particular interest in our analysis. The estimated ζ (0.030) is significantly different from zero, substantiating the relevance of the Box-Cox transformation of the indirect utility function (17). The liquidity constraint parameters ϕ_1 (-0.015) and ϕ_2 (-0.011) have expected negative signs and are significant at conventional significance levels. Thus disposable income and durables stock affect the liquidity constraint, but their effects are rather small. The value of ϕ_0 is also small but significant. Using (25), the degree of liquidity constraint is evaluated at the sample means of disposable income and durables stock, which gives the estimated ϕ_t value of 0.0062 with the *t* ratio of 2.6209. This clearly suggests weak evidence for liquidity constraints

[6] The calculated R^2 is the generalized R^2 for instrumental variables regressions (see Pesaran and Smith, 1994).

Table 2: Joint Estimation Results: Budget Share System and Euler Equation (t ratios in parentheses)

Parameter	Estimate	Parameter	Estimate	Parameter	Estimate
α_1	0.095 (5.712)	β_1	0.043 (3.118)	γ_1	0.131 (3.130)
α_2	0.012 (1.698)	β_2	0.018 (3.915)	γ_2	0.010 (0.741)
α_3	0.012 (1.758)	β_3	0.028 (6.242)	γ_3	—
α_4	0.212 (27.971)	β_4	0.044 (3.464)	γ_4	0.261 (5.409)
α_5	0.102 (6.187)	β_5	0.031 (2.811)	γ_5	0.061 (2.699)
α_6	0.024 (4.545)	β_6	0.003 (1.032)	γ_6	0.029 (3.352)
α_7	0.095 (7.195)	β_7	0.007 (0.510)	γ_7	0.201 (5.192)
α_8	0.035 (2.183)	β_8	0.066 (3.651)	γ_8	0.087 (1.972)
α_9	0.413 (12.705)	β_9	0.087 (6.704)	γ_9	1.220 (16.894)
τ_A	0.796 (19.417)	η	0.327 (12.908)	μ	-2.200 (-9.826)
ξ	0.030 (22.776)	ϕ_0	0.021 (3.894)	ϕ_2	-0.011 (-2.494)
ρ	0.074 (3.802)	ϕ_1	-0.015 (-3.840)		

Log-likelihood value: 1628.24

Test for the over-identifying restrictions (J-test):

χ^2 statistic = 81.784, p value = 0.768

Commodities	R^2	DW Statistic	Box-Pierce χ^2 statistic ($\chi^2_{2.5\%,6} = 14.45$)
q_1	0.989	1.089	12.900
q_2	0.884	2.094	5.000
q_3	0.958	1.621	5.860
q_4	0.826	1.178	6.080
q_5	0.719	2.045	4.360
q_6	0.943	0.988	8.730
q_7	0.900	1.575	4.770
q_8	0.989	1.461	6.050
κ	0.958	0.602	31.800

Notes: q_1 = food and non-alcoholic beverages, q_2 = alcoholic beverages, tobacco and narcotics, q_3 = clothing and footwear, q_4 = housing services,

q_5 = water and fuels, q_6 = health services, q_7 = transport services, q_8 = other non-durables and services, and k = durables stock.

Finally, the estimated time preference rate ρ of 0.074 means that consumers discount the utility of future consumption at an annual rate of 7.4%. To see this in proper perspective, we compare the time preference rate with the interest rate. During the sample period, the average annual interest rate was 7.13%. However, this average rate is misleading to represent the behavior of the interest rate during the sample period (see Table 1). The interest rate was above 10% during 1979-1992, but it has been falling since then -- from the value of 7.265% in 1993 to 2.236% in 2012. It remained below 2% for 2013 – 2018. Thus the time preference rate was greater than the interest rate for most of the sample period. This implies that Norwegian consumers, to a large extent, appear to be impatient, in the sense that they have a high time preference for present consumption relative to the risk-free interest rate.

4.3. Estimated Demand Elasticities and Relative Risk Aversion

Table 3 displays mean budget shares for commodities and estimated expenditure and price elasticities for nondurable and durable goods using (26) and (27) along with estimates of relative risk aversion (RRA) using (23) evaluated at the sample means of the variables. Two sets of estimates with and without durable goods are presented to see the bias resulting from ignoring durable goods, using nondurable goods only. Looking at the mean budget shares without durable goods, a substantial portion of expenditure on nondurable goods and services except for other goods is spent for housing services (20.4%), followed by food and non-alcoholic beverages (18.9%) and transport services (11.7%). When durable goods are included, it is important to note that durables expenditure is measured based on durables stock, not expenditure. With durable goods, a major portion of total consumption expenditure except for other goods is spent for durable goods (20.9%), followed by housing services (16.1%) and food and non-alcoholic beverages (15%).

As can be seen, ignoring durable goods leads to a significant bias in expenditure and price elasticities, underscoring the importance of accounting for durable goods. In particular, when durable goods are not considered, clothing and footwear has a wrong sign for the expenditure elasticity. Most nondurable goods are income-inelastic and can be classified as necessities.

Table 3: Estimation Results: Expenditure and Price Elasticities and Relative Risk Aversion (t ratios in parentheses)

Commodities	Mean Budget Shares: With Durables	Mean Budget Shares: Without Durables	Expenditure Elasticities: With Durables	Expenditure Elasticities: Without Durables	Own Price Elasticities: With Durables	Own Price Elasticities: Without Durables
q_1	0.150	0.189	0.675	0.566	-0.407	-0.514
	(6.193)	(5.807)	(7.950)	(5.313)	(-4.900)	(-5.134)
q_2	0.045	0.057	1.375	1.070	-0.690	-1.305
	(14.901)	(15.230)	(5.179)	(2.252)	(-5.512)	(-2.783)
q_3	0.061	0.077	1.370	-6.714	-0.782	-0.204
	(6.807)	(6.260)	(8.648)	(-0.002)	(-19.645)	(-1.154)
q_4	0.161	0.204	0.367	0.404	-0.257	-0.521
	(20.145)	(25.549)	(7.100)	(4.650)	(-4.879)	(-5.964)
q_5	0.052	0.065	0.386	0.232	-0.383	-0.057
	(12.283)	(14.211)	(5.693)	(1.160)	(-6.349)	(-0.358)
q_6	0.014	0.018	0.261	0.331	-0.253	-0.512
	(4.744)	(5.057)	(2.696)	(2.002)	(-2.449)	(-2.358)
q_7	0.093	0.117	0.366	0.373	-0.161	-0.121
	(17.029)	(22.834)	(4.552)	(2.690)	(-1.856)	(-0.978)
q_8	0.215	0.272	1.407	0.580	-0.640	-0.476
	(6.347)	(6.877)	(8.489)	(6.618)	(-6.585)	(-18.244)
k	0.209	—	0.685	—	-0.332	—
	(8.809)	—	(20.056)	—	(-19.873)	—
					With Durables	Without Durables
Coefficient of Relative Risk Aversion (RRA)					1.001	0.894
					(22.211)	(6.349)

Notes: q_1 = food and non-alcoholic beverages, q_2 = alcoholic beverages, tobacco and narcotics, q_3 = clothing and footwear, q_4 = housing services, q_5 = water and fuels, q_6 = health services, q_7 = transport services, q_8 = other non-durables and services, and k = durables stock.

However, alcoholic beverages, tobacco and narcotics, and clothing and footwear are income-elastic, though clothing and footwear are not strictly nondurable but semi-durable. Durable goods are also found to be a necessity like most nondurable goods. This result is markedly different from previous studies finding that durable goods are luxuries (see Clemens et al., 2019). This is due to the fact that traditional demand studies estimate the demand for durable goods in a flow form, but our analysis is based on a stock form. There are also studies for the United States based on a stock form finding durable goods as luxuries, but they are limited in scope and analysis with restrictive utility functions (see Mankiw, 1985). There may be some expensive or large durable goods that are luxuries, but most of them are small and can be treated as necessities.

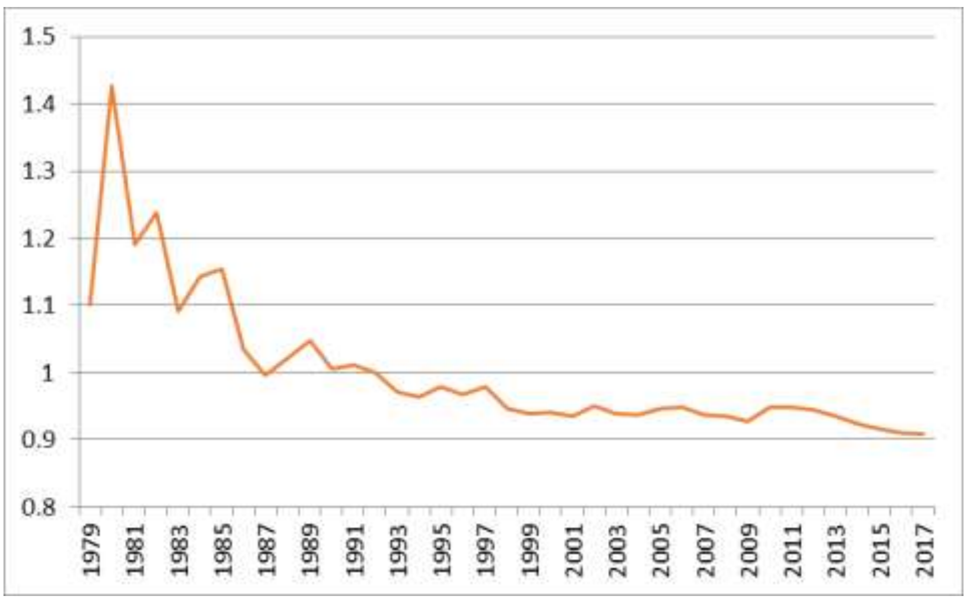
Estimated price elasticities also reveal a marked difference with and without durable goods. When durable goods are considered, all nondurable goods are price-inelastic. Durable goods are also found to be price-inelastic. There are studies estimating income and price elasticities of demand for Norwegian consumers (see the Appendix for literature review). However, they do not consider durable goods and use different groupings of nondurable goods, and thus they are not comparable to our results.

There has been a dramatic rise in the share of income spent on health expenditures in many countries, including Norway, and it is believed that this is a consequence of rising income or living standards (Hall and Jones, 2007). This would be the case if health care is a luxury. Acemoglu et al. (2013) investigated this issue by estimating the income elasticity of health care for the United States, and found that the estimate is much less than unity. This led them to conclude that rising income is unlikely to be a major driver of the rising health expenditure share of GDP. It has been often suggested, without evidence, that the invention of new and expensive medical technologies causes health spending to rise over time (see Hall and Jones, 2007).

The question that remains is, what is behind the notable trend in the rising health share of income? Our analysis provides some answer to this question for Norway. In particular, the estimated expenditure elasticity of health services when durable goods are included is 0.261, which is less than all other goods, meaning that health services are more necessary than other goods. Thus, the evidence is clear to reject that health care is a luxury; it can be rather considered a necessity. More importantly, we have an expenditure share equation for health care estimated in conjunction with other commodities [see (22)], with an average of 1.4% of total consumption spent on health care. From this equation, we can estimate the health share elasticities of income and prices, which are directly related to the income and price elasticities of health services in Table 3. From the estimated expenditure elasticity of health services, we get a health share elasticity of income of -0.739 with the *t* value of -2.696. This means that rising income has a negative effect on the health share of income, in direct contradiction to the conventional view (see Hall and Jones, 2007). The estimated price elasticity of health services is -0.253, yielding a health share elasticity of the health services price of 0.747 with the *t* value of 2.449. We then can conclude that the rise in the health expenditure share of GDP in Norway has been driven by rising health care prices or costs rather than by rising income. To a certain extent, this validates technological change as an explanation for the rising health share of income because the invention of new and expensive medical technologies raises the cost of providing health care.[7]

There is no significant difference between the RRA with and without durable goods. The RRA value with durable goods is lower than the usual a priori values considered reasonable for relative risk aversion ($1 < RRA < 5$) (see Cochrane, 2005). To further examine the behavior of RRA over time, Figure 3 presents its plot estimated with durable goods during the sample period. As can be seen, the degree of RRA has been decreasing over time. This implies that Norwegian consumers are, in general, not considered risk averse and have been less risk averse over the years. This runs counter to any attempt to explain the observed equity premium with an implausibly high level of risk aversion (see Mehra and Prescott, 1985; see also Kocherlakota, 1996).

Figure 3: Movement of Relative Risk aversion (RRA) over Time



[7] It is possible that the apparent increase in health care prices is spurious and caused by rapid progress in medical technology, leading to a higher quality of health care. Perhaps quality-adjusted prices have not risen by as much. We were not able to investigate this possibility.

4.4. Estimated Consumption Growth Equations

Table 4 presents results of estimating consumption growth equations based on total consumption (M_t), nondurable consumption (C_t), and durables stock (k_t). Two sets of results are presented in nominal and real specifications, and for each specification, a growth equation is estimated for M_t using (16) and for C_t and k_t. For the C_t and k_t growth equations, we estimated them by assuming that the two equations are independent and jointly related. For ρ and $\hat{\phi}$, we used their estimated values; see Section 4.2. All growth equations are estimated by an instrumental variables approach discussed in Section 4.1.

Looking at the nominal specification for total consumption, there are significant price effects with the largest one being p_1 (price of food and non-alcoholic beverages) with the value of -0.716. They are followed by p_7 (price of transport services) with the value of 0.611 and p_2 (price of alcoholic beverages, tobacco and narcotics) with the value of 0.540. Most of the nondurables price changes have positive effects on total consumption growth. The user cost of durable goods (r^k) has a positive and significant value of 0.235. On the one hand, the interest rate has a rather modest effect on total consumption growth with the value of 0.193, but it is not significant. The liquidity constraint has more effect than the interest rate on total consumption growth, but it is insignificant. Remarkably, however, conditional variance has a large and significant effect on total consumption growth.

When total consumption is broken into nondurable and durable consumption, the effects are different. Nonjoint and joint estimation also give different results. Looking at joint estimation results, most nondurables prices turn out to be insignificant for nondurable consumption and durables stock growth. The user cost has a small effect on nondurable consumption and durables stock growth, though it is significant for nondurable consumption growth. The interest rate has a large, though insignificant, effect on nondurable consumption, but it has a wrong sign for durable goods. The liquidity constraint has an insignificant effect on nondurable and durable consumption. However, conditional variance has large and significant effects on both nondurable and durable consumption; this is especially so for durable goods.

Real specifications do not allow for the relative price effects of nondurable goods. Although the estimated coefficients have different values and signs for the user cost, the interest rate, and the liquidity constraint, the effect of conditional variances is noticeable as in the case of nominal

Table 4: Estimation Results: Consumption and Durables Stock Growth Equations (t ratios in parentheses)

Regressors	Nominal Specification					Real Specification				
		Nonjoint Estimation		Joint Estimation			NonjointEstimation		Joint Estimation	
	$\Delta \ln M_{t+1}$	$\Delta \ln C_{t+1}$	$\Delta \ln k_{t+1}$	$\Delta \ln C_{t+1}$	$\Delta \ln k_{t+1}$	$\Delta \ln M_{t+1}$	$\Delta \ln C_{t+1}$	$\Delta \ln k_{t+1}$	$\Delta \ln C_{t+1}$	$\Delta \ln k_{t+1}$
Constant	0.028	0.030	0.007	0.020	0.029	0.256	0.043	0.009	0.115	0.005
	(1.954)	(3.445)	(2.040)	(0.792)	(3.272)	(3.020)	(4.654)	(0.869)	(3.967)	(0.543)
$\Delta \ln p_{1t+1}$	-0.716	-0.543	—	-0.434	-0.288	—	—	—	—	—
	(-2.269)	(-2.916)	—	(-0.508)	(-0.919)	—	—	—	—	—
$\Delta \ln p_{2t+1}$	0.540	0.130	—	0.206	0.053	—	—	—	—	—
	(3.311)	(1.064)	—	(0.252)	(0.306)	—	—	—	—	—
$\Delta \ln p_{3t+1}$	-0.014	-0.023	—	-0.330	0.045	—	—	—	—	—
	(-0.101)	(-0.248)	—	(-0.806)	(0.339)	—	—	—	—	—
$\Delta \ln p_{4t+1}$	-0.502	-0.047	—	-0.213	-0.535	—	—	—	—	—
	(-2.077)	(-0.265)	—	(-0.438)	(-2.291)	—	—	—	—	—
$\Delta \ln p_{5t+1}$	0.038	-0.006	—	0.040	0.070	—	—	—	—	—
	(0.621)	(-0.137)	—	(0.185)	(0.988)	—	—	—	—	—
$\Delta \ln p_{6t+1}$	-0.408	-0.038	—	-0.065	0.149	—	—	—	—	—
	(-1.794)	(-0.292)	—	(-0.119)	(1.106)	—	—	—	—	—
$\Delta \ln p_{7t+1}$	0.611	0.345	—	0.500	0.183	—	—	—	—	—
	(3.724)	(3.185)	—	(1.542)	(1.325)	—	—	—	—	—
$\Delta \ln p_{8t+1}$	0.216	0.110	—	0.197	0.332	—	—	—	—	—
	(1.777)	(1.475)	—	(0.608)	(3.796)	—	—	—	—	—
$\Delta \ln r^k_{t+1}$	0.235	—	0.005	0.074	0.005	0.180	—	-0.001	0.053	-0.002
	(7.271)	—	(1.240)	(4.772)	(1.253)	(3.138)	—	(-0.085)	(2.689)	(-0.240)
$\ln\left(\frac{1+r_t}{1+\rho}\right)$	0.193	0.079	-0.096	0.411	-0.073	0.156	-0.074	-0.101	-0.104	-0.093
	(1.124)	(0.626)	(-3.129)	(1.086)	(-0.551)	(0.831)	(-0.800)	(-3.004)	(-1.087)	(-2.796)
$\ln(1-\hat{\phi}_t)$	0.320	0.349	0.033	0.136	0.236	-0.366	4.091	0.057	0.327	0.033
	(1.269)	(1.824)	(0.684)	(0.275)	(1.704)	(-1.147)	(5.080)	(1.124)	(1.763)	(0.671)
$\sigma^2_{M_{t+1}}$	2.766	—	—	—	—	3.962	—	—	—	—
	(4.959)	—	—	—	—	(7.532)	—	—	—	—
$\sigma^2_{C_{t+1}}$	—	4.836	—	4.126	—	—	0.426	—	4.180	—
	—	(11.049)	—	(2.372)	—	—	(2.220)	—	(6.499)	—
$\sigma^2_{k_{t+1}}$	—	—	9.006	—	9.121	—	—	8.467	—	9.076
	—	—	(17.256)	—	(5.118)	—	—	(18.891)	—	(18.042)
R^2	0.899	0.971	0.910	0.892	0.970	0.769	0.699	0.959	0.692	0.956
DW	2.009	1.493	0.809	1.367	1.181	1.457	1.620	0.821	1.258	0.731
P*	0.318	0.569	0.580	0.183		0.745	0.115	0.376	0.258	

Notes: M = total expenditure, C = nondurable consumption, k = durables stock, durables stock, p_1 = price of food and non-alcoholic beverages, p_2 = price of alcoholic beverages, tobacco and narcotics, p_3 = price of clothing and footwear, p_4 = price of housing services, p_5 = price of water and fuels, p_6 = price of health services, p_7 = price of transport services, p_8 = price of other nondurables and services, r^k = user cost of durable goods, r = interest rate. ρ = time preference rate, $\hat{\phi}$ = liquidity constraints, Y^d = disposable income, σ_M^2 = conditional variance of total expenditure measured by its realized value $(\Delta \ln M)^2$, σ_c^2 = conditional variance of nondurable consumption measured by its realized value $(\Delta \ln C)^2$, and σ_k^2 = conditional variance of durable goods measured by its realized value $(\Delta \ln k)^2$. DW = Durbin-Watson statistic, and P* = p value of the over-identifying restriction test (J-test).

specification.

From the above discussions, we find it important to analyze total consumption growth together with nondurable consumption and durables stock growth to fully understand the consumer's intertemporal behavior about consumption. There are relative price effects on total consumption growth, but it effects are not significant in nondurable consumption and durables stock growth. With the weak evidence of liquidity constrains (see Table 2), we find that liquidity constraints do not have an important influence for Norwegian consumption. However, there is a considerable effect of uncertainty on nondurable and durables consumption. Although there is more uncertainty found in nondurable consumption than in durables consumption (see Table 1 with a discussion in Section 2.1), durables consumption is more sensitive than nondurable consumption to uncertainty. This provides precautionary savings affecting all consumption goods and additional wait and see effects for durables consumption (see Gudmundsson and Natvik, 2012). Precautionary savings under uncertainty is particularly relevant in times of economic weakness, as is observed during the current corona virus pandemic (see Smith, 2020, for evidence in the United States).

It is, however, important to note that the elasticity of intertemporal substitution (EIS) for total consumption as well as nondurable consumption, and durable goods is low and insignificant. This is not unexpected and is consistent with Hall's (1988) assertion that (nondurable) consumption growth is completely insensitive to changes in interest rates, and hence, the EIS is very close to zero. Almost all studies on intertemporal substitution in consumption are based on the use of nondurable goods excluding durable goods. Evidence is mixed, but most estimates in previous studies are, by and large, much larger than zero (see Havranek, 2015 and Thimme, 2017 for a survey of evidence). The EIS for durable goods is low and negative. This is surprising because durable goods are widely considered to be very sensitive to changes in the interest rate. While this may be true for big durable good items such as automobile or housing, it may not be the case for most durable good items. For these goods, the interest rate may not be an important factor determining the consumer's purchase decision.

Further, housing is excluded in durable goods in Eurostat on which our data are based. These results suggest that the EIS in total consumption is close to zero.

Importantly, however, the EIS measures the response of consumption growth to a *temporary* change in the interest rate. The negligible value of this elasticity is largely attributed to a lack of sufficient intertemporal variations or year-to-year temporary fluctuations in the interest rate[8] (see Table 1). To the extent that this lack of variations can be interpreted as some evidence for the presence of permanent changes in the interest rate,[9] the absence of intertemporal substitution in nondurable consumption and durable goods is expected. This is because the interest rate changes infrequently and its change can be perceived as permanent by consumers in the sense that it will last for many periods. This permanent change in the interest rate does not induce an intertemporal substitution effect, but a temporary change that lasts for short periods does (see Section 3.1.4 for a discussion). Then, with no intertemporal substitution effects, the observed fall in nondurable and durable spending subsequent to a rise in the interest rate can be explained by viewing this rise as *permanent* by consumers with a negative wealth effect. If we treat consumers as net borrowers, a *permanent* rise in the interest rate decreases their wealth, thereby causing them to decrease nondurable and durable spending. (This is also true for stock holders, because an permanent increase in the interest rate lowers the present discount value of their stocks.)

There are studies on consumption behavior for Norwegian consumers (see the Appendix for a literature review). They estimate consumption functions by including income, wealth, the interest rate, and other variables. It is well known, however, that estimation of a consumption function suffers from some fundamental problems (see Hall, 1978), and the Euler equation is a common framework in modern analysis of consumption (see Section 3.1.4), which is adopted in our study. Although studies on Norwegian consumption fail to account for many relevant issues examined in our analysis, there are studies accounting for uncertainty for Norwegian consumers (see Gudmundsson and Natvik, 2012; Jansen, 2015; Fagereng and Halvorsen, 2016). Notably,

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[8] Crump et al. (2021) provided a promising approach to estimating the EIS. They used direct measures of households' subjective expectations of consumption growth and inflation, rather than their realized values. The inflation expectations data provide variation in the perceived real interest rate. Assuming implicitly that the nominal interest rate is constant over time, they estimated planned consumption growth against expected inflation and found an EIS of about 0.5.

[9] Although changes in the interest rate are temporary, insofar as they are persistent, such changes can be viewed as permanent by consumers.

Gudmundsson and Natvik (2012) employed a structural VAR framework with two different measures of uncertainty – volatility indexes from financial markets and the frequency with which economic uncertainty is mentioned in the Norwegian press. They found a considerable response in nondurable and, in particular, durable consumption to uncertainty. This is certainly consistent with our finding about uncertainty. Aastveit et al. (2020) examined the effects of debit card transactions on consumption for Norwegian households, and found that Covid-induced uncertainty greatly reduced their consumption. The reduced consumption is likely accompanied by an increase in savings. Although we have found no formal study in Norway for this possibility (see Smith, 2020, for evidence in the U.S.), a Google search for Norway, indeed, reveals that "Savings in equity funds in Norway more than doubled since the start of the pandemic." This is, of course, what is expected from our analysis of uncertainty.

5. Summary and Conclusion

While there are many studies on consumer demand and consumption, they are conventionally conducted independent of each other. The tenor of this study is that the consumer's intratemporal and intertemporal consumption decisions cannot be separated; hence consumer demand and consumption cannot be studied in isolation. To address this point, we have therefore presented and estimated an integrated model of consumer behavior for Norwegian consumers for 1979-2018 with allowance for durable goods and liquidity constraints. We find that traditional demand analyses ignoring durable goods leads to a significant bias in the elasticities of nondurable goods. Although most nondurable goods including health services are necessities, alcoholic beverages, tobacco and narcotics, and clothing and footwear are found to be income-elastic. Durable goods are also found to be necessities and price-inelastic like most nondurable goods. Norwegian consumers are, in general, impatient with high time preference for present consumption relative to the risk-free interest rate. They are not risk averse and have been less risk averse over time. There is weak evidence for liquidity constraints, which have no important influence on consumption. No strong evidence exists for intertemporal substitution in consumption of nondurable and durable goods. However, there is a considerable effect of uncertainty on nondurable consumption and particularly in durable goods, inducing an increase in precautionary saving with reduced consumption, as is observed during the current Covid-19 pandemic.

These results are informative to understand Norwegian consumer behavior relative to previous studies. However, to draw firm conclusions about consumer demand and consumption, more empirical work may be in order with a possibly refined empirical model and better use of the data. Yet, our analysis indicates the relevance of the integrated model that can be exploited to improve traditional micro studies on consumer demand as well as macro studies on consumption/saving.

Appendix: Literature Review on Consumer Behavior in Norway

This appendix reviews important studies relating to consumer behavior in Norway since 1978. To draw out a broad picture of these studies, we elucidate the nature of the fundamental approaches taken by the researchers and conclusions that they have finally reached.

As indicated in the Introduction, conventional studies on consumer behavior are divided into micro analysis of consumer demand and macro analysis of consumption; studies on Norwegian consumer behavior are not the exception. In particular, consumer demand analysis is usually concerned with estimating price and income elasticities for goods and services conditional on total expenditure, while in consumption analysis, researchers focus on estimating the intertemporal pattern of consumption by including a variety of explanatory variables. In almost all of these studies, nondurable goods are excluded in analysis, and none of them accounts for the joint link between the consumer's intratemporal and intertemporal decisions.

Micro Studies on Consumer Demand

Most micro studies that model private consumption in Norway are based on time-series data. The early work of Snella (1978) established the basic methodology for subsequent studies. Despite its simplicity and hence its wide-spread popularity, this approach completely ignores the intertemporal allocation problem of consumption, implying that it is incapable of handling economic problems that are intrinsically intertemporal.

In Snella (1978), models of Norwegian private consumption from 1947 to 1974 were estimated based on a modification of the well-known Linear Expenditure System (LES) in which habit formation effects and nonlinearity of Engel curves were incorporated into the models. Results generally indicated that the LES with habit formations fit the data very well, while demand for medical services and housing services and energy, as well as for beverages and tobacco and other goods and services are profoundly affected by habit formations.

Norwegian private consumption pattern was further examined by Rickertsen and Vale (1996) and Rickertsen (1996). In Rickertsen and Vale (1996), the static and dynamic versions of Linearized Almost Ideal Demand System (LAIDS) were estimated using aggregated and disaggregated time series data covering the period 1960-1991. Results based on aggregated data indicates that the hypotheses of homogeneity and symmetry are decisively rejected, in line with other famous studies such as Deaton and Muelbauer (1980b) and Johnson et. al. (1986). Of interest is that the expenditure elasticities of fish and cheese implied by the static LAIDS are negative and insignificant, while the own-price elasticity of egg is positive and insignificant.

In Rickertsen (1996), five types of meat and fish consumption from 1960-1992 were considered and a “dynamic switching” Almost Ideal Demand System was developed in order to capture the structural change in private consumption. The author also acknowledged that commodity prices in the models are endogenous, leading him to use the three-stage least square technique rather than the conventional method to estimate the models. Overall, results show a graduate change in the demand for meat and fish during the 1980s and there have been statistically significant shifts towards fish and chicken and away from beef.

Norstrom and Moan (2009) investigated the relationship between alcohol consumption and sickness absence using annual data for Norway covering the period 1957-2001. Based on Box-Jenkin methodology, it is shown that a 1% increase in alcohol consumption is associated with a 13% increase in sickness absence among men. By contrast, the effect of alcohol consumption on sickness absence was not significant for women.

A few studies of Norwegian private consumption are based on household level data. Examples include Rickertsen and Vale (1996) and Nesbakken (1999). In Rickertsen and Vale (1996), the “static” LAIDS was estimated using household level data which was collected as repeated cross-sections over the period 1982-1988. As expected, their F-test results indicated that conditions of homogeneity and symmetry are rejected in most cases. On the other hand, the estimated own-price and expenditure elasticities have reasonable magnitudes and expected signs; these are inconsistent with their estimates using aggregated and disaggregated time series data.

Nesbakken (1999) using a discrete-continuous choice model focused on Norwegian residential energy consumption for the years 1993-1995. Her main findings indicated that parameter estimates are stable from year-to-year. Furthermore, the short run own price elasticity of energy for all households is about -0.50, although the own price elasticity of energy of high-income households is twice as high (in absolute values) as the elasticity for low-income households.

Macro Consumption Studies

All studies on Norwegian consumption are conducted with no regard to intratemporal allocation problem of consumption. The first attempt to estimate a long run Norwegian consumption function is provided by Brodin and Nymoen (1992). In their consumption function, income and wealth are treated as regressors, and the the wealth variable is defined as the household’s net financial wealth plus the nominal values of the residential capital stock. Their results showed that income and wealth are “weakly exogenous” with respect to long run parameters. Of interest to macroeconomists are the estimated income and wealth elasticities (0.56 and 0.27 respectively), although these estimates were questioned by several critics. For instance, Magnussen and Moum (1992) claimed that their results may be misleading, since their adopted housing price index (used to compute the wealth variable) did not reflect the actual prices relevant for consumers. Magnussen and Moum also showed that when a new definition of housing price index is employed, results based on Brodin and Nymoen’s specification are altered radically; they found that the consumption function in Norway has undergone a structural change after 1985 that is completely inconsistent with Brodin and Nymoen’s (1992) main conclusion.

Further studies on Norwegian macro-consumption function were based on the approaches developed by Brodin and Nymoen (1992) and Magnussen and Moum (1992), and their major findings are summarized in Landsem (2016, page 28). For example, Ekeli (1992) modified Brodin and Nymoen's model by using a broader (including stocks and bonds) definition to measure wealth variable, while this modification does not change the parameter estimates of the model drastically. Subsequently, Brubakk (1994) expanded Magnussen and Moum's (1992) model by including a dummy variable to capture the effect of deregulation of the credit market. Interestingly, he found that the estimated wealth elasticity is less than half of that of Brodin and Nymoen (1992).

In Erlandsen and Nymoen (2008), they analyzed empirically the impacts of real interest rates and changes in the age distribution of population on aggregation consumption. Based on Norwegian quarterly time series data, results revealed that changes in the age distribution have significant and life cycle consistent effects on aggregate consumption. In addition, when age structure effects were taken into account, the effect of real interest rate on aggregation consumption turned out to be significant.

A more recent study by Jansen (2013) extended Brodinand Nymoen's (1992) model by incorporating the real interest rate as an additional exogenous variable. Results that are of interests to macroeconomists are that wealth and real interest rate elasticities from 1971-2008 were 0.15 and -0.71 respectively, whereas the income elasticity estimate was 0.85 which is much higher than those reported in previous studies.

After 2008, Norwegian economy experienced substantial structural changes in consumption pattern and saving behavior. Since the financial crisis, Norwegian private consumption has been falling as a share of household disposable income. In order to explain these phenomena, conventional consumption models were further modified and tested by more advanced econometric techniques. Examples are Gudmundsson and Natvik (2012), Jansen (2015), Anderson et. al. (2016), and Landsem (2016). In Gudmundsson and Natvik (2012), they utilized the vector auto regression (VAR) model to assess how Norwegian household consumption responds to variation in economic uncertainty. Based on their findings, they claimed that increase in uncertainty is followed by significant contractions in household consumption, though the fall in total consumption is not solely caused by a fall in durables good consumption. Overall, they concluded that the fall in Norwegian consumption growth after 2008 was due to both precautionary behavior and delays of irreversible decisions.

In a more recent paper, however, Jansen (2015) asserted that the declining Norwegian consumption growth is due to the pension reform of 2011, a growing number of international migrants, stricter requirements for money borrowing, demographic changes in the population, and an increased saving incentive for youth. Jansen's argument was questioned and examined empirically by Andersen et al. (2016) who contended that stricter credit conditions and household's precautionary behavior should be the dominant causes of stagnant consumption growth.

The latest study included in this review was undertaken by Landsem (2016), who used the cointegration analysis to build up a new long run consumption function that is capable to explain the structural change since 2008. Two interesting results emerged from Landsem's study. Firstly, the impact of income distribution (measured by Gini ratio and wage shares) on aggregate consumption is statistically insignificant. Secondly, the author found empirical support for including financial and housing wealth variables in the long run model. Results also showed that financial wealth in the aggregate consumption function has the largest effect, confirming that cash and bank deposits in Norway are held as a mean of transactions rather than a store of wealth.

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