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Asset Pricing with nonlinear Consumption Services

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Statement of Authorship

I hereby declare that the thesis submitted is my own work. All direct or indirect sources used are acknowledged as references. I further declare that I have not submitted this thesis at any other institution in order to obtain a degree.

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Resumo

MORAIS, B.F. Precificação de ativos com fluxo de serviços não linear. 2023. Dissertação (Mestrado em Economia Aplicada) - Faculdade de Economia, Administração e Contabilidade de Ribeirão Preto, Universidade de São Paulo, 2023.

Quando o fluxo de serviços de bens duráveis é considerado linear no estoque de bens duráveis, a dinâmica do últimos é fortemente dependente da dinâmica do primeiro. Isso permite que o CCAPM atinja maiores níveis de risco de consumo, ajudando a resolver alguns dos muitos quebra-cabeças que envolvem o modelo. No entanto, argumentamos que essa implementação não deve ser tomada como certa. Exploramos uma forma alternativa de medir o fluxo de serviços de bens duráveis, e nossos resultados sugerem que o consumo de bens duráveis pode reduzir, ao invés de aumentar, o risco de consumo que o agente enfrenta.

Palavras-chave: Consumption Services, Bens Duráveis, CCAPM

Abstract

MORAIS, B.F. Asset Pricing with nonlinear Consumption Services. 2023. Dissertação (Mestrado em Economia Aplicada) - Faculdade de Economia, Administração e Contabilidade de Ribeirão Preto, Universidade de São Paulo, 2023.

When the service flow from durable goods is taken to be linear on the stock of durables, the dynamics of of the latter are heavily dependent on the former. This allows the CCAPM to attain greater levels of consumption risk, helping to solve some of the many financial puzzles that surround the model. However, we argue that this implementation should not be taken for granted. We investigate an alternative approach to quantify the flow of services from durable goods. Our findings indicate that durables consumption has the potential to decrease, rather than increase, the consumption risk that households encounter.

Keywords: Consumption Services, Durable Goods, CCAPM

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Introduction

One of the key challenges in the field of asset pricing is the notable disparity between the theoretical consumption-based asset pricing model (CCAPM) and empirical observations. The Euler equation suggests a relationship between excess returns, consumption, and various risk factors incorporated in the optimization problem. After linerization, the size of the household exposure to these factors is captured by the coefficient associated with each specific component. However, excess returns exhibit high volatility, while aggregate consumption remains relatively stable. As a result, regression analyses tend to yield poor results and may entail unrealistic structural parameters. Hence, estimations of systemic risk using this model are controversial. For a comprehensive overview of this issue in equity literature, refer to the works of Cochrane (2017), Savov (2011), Constantinides and Duffie (1996), Epstein and Zin (1991), Constantinides (1990). Similarly, in the foreign exchange literature, researchers such as Gonçalves et al. (2022), Ferreira and Moore (2015), Burnside (2011), Lustig and Verdelhan (2011) have also acknowledged and discussed this issue.

Yogo (2006) provides a seminal contribution. His consumption model nests four different versions of the CCAPM as special cases. Intraperiod utility is a constant elasticity of substitution (CES) function of the consumption of services from nondurable and durable goods. Intertemporal utility follows the recursive form proposed by Epstein and Zin (1991). The model was used to successfully explain the cross-sectional and time variation in expected stock returns. Other authors have also used his model to explain foreign exchange currency returns and carry trade (see Lustig; Verdelhan, 2011). His model works empirically because when the elasticity of substitution between the two consumption goods is sufficiently high, marginal utility rises when durable consumption falls. Consequently, if the service flow from durable goods is sufficiently volatile, consumption changes to match the variation in excess returns. As noted by the author, the high cyclicality of the services flowing from durable goods is the key ingredient in explaining the observed facts about expected stock returns.

Nonetheless, there is an empirical limitation that is inherent to durable consumption models. The primary issue arises from the unobservable and unmeasured nature of the services derived from durable goods. To overcome this challenge, it becomes necessary to assume a technology capable of converting consumption goods purchased today into service flows in the future. Yogo's (2006) model, for instance, implicitly assumes that the service flow from the durable good is linear in the stock of the durable good. This approach shares similarities with previous models proposed by Dunn and Singleton (1986) and Ogaki and Reinhart (1998), but it should not be taken for granted.

Note that the aforementioned assumption imposes the dynamics of the stock on the consumption process. For it to hold, Households need to utilize durable goods acquired in the past following a "rule of thumb": regardless of marginal utility, services flow from the stock at a fixed proportion. This is as problematic as much as it is convenient. The stock is heavily dependent on expenditure, since expenditure on durables is relatively volatile, this dependency helps the model attain desired levels of consumption risk. However, expenditure only captures consumption at the time of purchase, ignoring the utility bearing services that a good might provide in between purchases. Because of that, a linear approach to the service flow overlooks the potentail hedging advantages provided by durable goods. For instance, when there is an economic downturn and a household's financial portfolio experiences a decline, their budget becomes tighter, leading to reduced expenditure and limited stock accumulation. However, this does not need to imply a decrease in consumption growth. Instead, households can adapt by temporarily increasing the utilization of their existing durable goods. As a result, households with larger stocks of durable goods could experience lower levels of risk, thereby mitigating the potential negative impacts of economic fluctuations.

Nevertheless, those issues are largely ignored by the literature. The reasons for this are manyfold, but at least two facts ought to contribute heavily. The first one is that there are no official measures for the service flow. The second is that establishing a less restrictive technology for producing services from durable goods complicates the underlying optimization problem. We propose an alternative approach to tackle durables consumption, while still working around those obstacles. This is achieved through the user cost principle (UCP) due to Diewert (1974) and Jorgenson (1963). It states that the multiplication of the stock of an asset by its rental price gives the value of the services afforded by that asset over the relevant time period. This principle is readily applicable to consumer goods, and allows us to build a direct measure of the services flowing from durable goods. With the UCP, services are seen as flowing from the stock through the implicit rental price of that stock. Thus the volatility of the service flow is less dependent on the volatility of expenditure. In fact, even if expenditure is highly volatile, the rental price might offset how much of that volatility reaches the final consumption process. We explain this approach in detail in section 1.2

By and large, the general question of this dissertation regards the asset pricing implications of durable goods consumption. More specifically, we aim to explore what a UCP interpretation of the flow of services tells us about consumption risk within the CCAPM framework. We build our consumption measure following Patterson (1992), who makes use of the aforementioned UCP in order to assemble a divisia quantity index for the aggretate flow of services. Dubbed here Consumption Services (CS), this measure offers an alternative understanding of how goods with a durability aspect are consumed over time. We then compare risk estimates derived from the use of CS with NIPA's personal consumption expenditure and other consumption measures proposed by the literature. Our work is presented in the following text as follows: in the first part o Chapter 1, we review the theoretical and empirical literature related to our general question. In the second part, we introduce the consumption services measure. Chapter 2 presents the data and empirical results. The last section concludes.

1 Asset Pricing With Durable Goods

1.1 The Literature

The modern asset pricing literature follows the seminal work of Lucas (1978) and Breeden (1979), with the development of the consumption based asset pricing model. Within the realm of Macro-Finance, the CCAPM and its many variations are firmly established as the main theoretical basis for empirical analysis of the relationship between asset prices and economic fluctuations (see Cochrane, 2017). In general, forward looking consumers choose consumption and savings for the present and future in order to maximize their expected lifetime utility. They are limited by an intertemporal budget constraint, as consumption may not exceed the amount of lifetime resources available for the acquisition of goods and assets. As a result, the expected return on an asset is related to its "consumption risk", that is, how much uncertainty in consumption would come from holding the asset. Assets that lead to a large amount of uncertainty offer large expected returns, as investors want to be compensated for bearing consumption risk.

Following Constantinides, Harris and Stulz (2013), the standard model with constant relative risk aversion (CRRA) utility is the simplest within Macro-Finance. Agents choose a consumption path $\{C_t\}_{t=0}^{\infty}$ and shares $\{w_i\}_{i=0}^{J}$ in order to maximize

$$E_0[U_t(C_t)] = E_0\left[\sum_{t=0}^{\infty} \beta^t \frac{C_t^{1-\gamma}}{1-\gamma}\right], \gamma \geq 0, \gamma \neq 1 \tag{1.1}$$

subject to

$$A_{t+1} = \left(\sum_{i=1}^{J} w_i R_{i,t+1}\right)(A_t + Y_t - C_t) \tag{1.2}$$

where $\sum_{i=1}^{J} w_i = 1$. C_t, A_t and Y_t are time t consumption, wealth and endowment. γ is the relative risk aversion coefficient, β is the intertemporal discount rate, w_i is the share of savings to be invested on the i-th asset and $R_{i,t+1}$ is the return of that same asset in the next period. Solving recursively, this problem implies the Euler equation given by

$$E_t\left[\beta\left(\frac{C_{t+1}}{C_t}\right)^{-\gamma} R_{i,t+1} - 1\right] = 0, \forall i \tag{1.3}$$

Assuming that the conditional distribution of the term inside brackets is log-normal, the following pricing conditions can be obtained from equation (1.3)

$$E_t[r_{i,t+1} - r_{f,t+1}] = -\frac{1}{2}\sigma_i^2 + \gamma\sigma_{i,c} \tag{1.4}$$

$$r_{f,t+1} = \gamma E_t[\Delta c_{t+1}] - \left(\ln\beta + \frac{1}{2}\gamma^2\sigma_c^2\right) \tag{1.5}$$

where $r_{f,t+1} \equiv \ln R_{f,t+1}$, with R_f representing the risk free rate (i.e, the rate R_f whose probability distribution is known and independent from every other distribution in the economy). Furthermore, $r_{i,t+1} \equiv \ln R_{i,t+1}, c_t \equiv \ln C_t, \Delta c_{t+1} \equiv c_{t+1} - c_t, \sigma_i^2 = \text{var}[r_{i,t+1}]$, $\sigma_{i,c} \equiv \text{cov}_t[\ln r_{i,t+1}, \Delta c_{t+1}]$. These two equations illustrate some of the analytical power of the model. They also represent some of it's biggest shortcomings.

Take for example equation (1.4). It identifies the quantifiable aspects of an asset that steers its "price". Expected excess returns decrease with volatility and increase with the covariance between returns and consumption growth. These properties constitute an elegant description of the feature of recessions that induces the pricing diversity in the cross-section of returns: consumption risk. Pure volatility as measured by the variance of a stock is not a fundamental driver of greater returns. The kind of risk agents are unwilling to bear, and therefore lead them to require greater compensation, is very specific. If the stock value of an asset tends to fall at particularly inconvenient times, that is, when consumption is also falling and therefore marginal utility is high, then $\sigma_{i,c}$ is numerically high and positive. Thus, in order to satisfy the equation, expected excess returns must go up. Equation (1.5), on the other hand, states that the risk free rate grows with consumption growth and decreases with the variance of consumption. It presents the same trade-off between risk and return we just alluded to, but through a different angle. When consumption grows steadily and there is little to no variance in consumption, the risk free rate will be high, as there is very little consumption risk in the economy.

Although equations (1.4) and (1.5) provide a sound theoretical explanation to asset pricing, both of them have been plagued by so called "puzzles" in the literature. The first of them illustrates the mismatch between data an theory first observed by Mehra and Prescott (1985). Aggregate consumption is smooth and excess returns are highly volatile. Thus, $\sigma_{i,c}$ is numerically small. Given a reasonable excess return of, say, 4%, a market volatility of about 16% on a annual basis and a weak covariance of 0.1%, the risk aversion γ required to satisfy the equation is 120. Although there is a wide range of measures of the coefficient of relative risk aversion, the most commonly accepted estimates lie between 1 and 3. Not even close to the required value. This means that the classic CCAPM is largely unable to explain excess returns, unless one is willing to accept unrealistic structural parameters. This particular problem has been called the "equity premium puzzle", as it was first observed in equity markets. But it is certainly not exclusive to them. For example, when estimating four consumption based models with currency portfolios, Lustig and Verdelhan (2011) attain relative risk aversion coefficients that range from 92 on the lower end, to 113 in the higher end.

The second equation implies a consistently higher risk-free rate than the observed rate when we calibrate γ to a reasonable size. This phenomenon is known as the "risk-free rate puzzle" and represents the same underlying issue approached from a different perspective. In fact, most financial puzzles can be attributed to a common factor: empirical data indicates that households face significantly higher consumption risk than what is anticipated in the model. Extensive research has been conducted to address this issue, exploring alternative preferences, market structures, and data sources. Some of the approaches taken include studying habits (Campbell; Cochrane, 1999), long-run risks (Bansal; Yaron, 2004; Bansal; Kiku; Yaron, 2012), idiosyncratic risks (Constantinides; Duffie, 1996), disasters (Rietz, 1988; Barro, 2006; Barro, 2009), heterogeneous preferences (Gârleanu; Panageas, 2015), alternative measures of consumption (Savov, 2011), and non-separable preferences (Piazzesi; Schneider; Tuzel, 2007; Lustig; Verdelhan, 2011; Yogo, 2006).

Our work aligns closely with the existing literature that examines the role of durable goods in asset pricing. In this context, "durables" refer to goods that provide utility over time through a continuous stream of consumption services. To accurately represent durables in the household utility function, it is crucial to consider the value of this stream. However, empirical analysis in this area faces significant challenges. Unlike non-durables and services, there is a lack of official sources to measure the stream of consumption services associated with durables.

As pointed out by Patterson (1992), early researchers mistakenly relied on the prevailing practice of defining aggregate consumption as total current expenditure. This approach is flawed because expenditure alone fails to capture the consumption of durables adequately. There are two primary reasons for this inadequacy. Firstly, expenditures on durables occur at a specific point in time, overlooking the ongoing utility derived from the subsequent services provided by these goods. Secondly, there is often a significant time lag between the expenditure on durable goods and the realization of utility from the stream of services they offer. In the national product accounts, for instance, a good is classified as durable if its average useful life is at least three years. Therefore, NIPA's expenditure on durable goods may occur years before the actual consumption of their services takes place.

The modern literature has made significant advancements in addressing this issue, with two main specifications identified. The first specification addresses the problem effectively by assuming additively separable consumption services from other inputs in the utility function. This assumption allows researchers to derive empirical results exclusively based on the analysis of those other inputs. The approach employed by Hansen and Singleton (1996) in estimating an ICAPM and by Hall (1978) in examining the permanent income hypothesis relied on this methodology. Nevertheless, it is worth noting that evidence indicates separability assumptions may introduce misspecification bias (Eichenbaum; Hansen, 1990; Ogaki; Reinhart, 1998). On the other hand, the second approach involves modeling services as flowing from households stock of durable goods (Dunn; Singleton, 1986; Ogaki; Reinhart, 1998; Yogo, 2006). By explicitly capturing the continuous flow of utility derived from durables over time, this approach provides more accurate representations of household behavior and asset pricing dynamics. Nonetheless, as mentioned in our introductory section, these specifications may not fully capture the decision-making process of households regarding the acquisition and consumption of durable goods.

In the following sections, we present a novel approach to address this problem within the asset pricing literature. Instead of bypassing the issue through additive separability or imposing an arbitrary technology for transforming goods into services, we propose the implementation of Patterson's (1992) attempt to directly measures the service flow.

1.2 Measuring the Service Flow

The service flow from durable goods, which occurs outside of markets, is difficult to observe directly. To estimate its size, we often rely on proxy variables such as CO_2 emissions (see Chen; Lu, 2017), or even garbage production (see Savov, 2011). However, these measures are imperfect due to the diverse nature of durables. For instance, electric cars and gasoline cars provide similar services, but if we use CO_2 emissions as a measure, the utilization of electric cars would be significantly underestimated. Similarly, if we measure the service flow of gasoline cars based on electricity consumption, it would be inaccurate.

However, it is possible to enhance the measurement of the service flow by considering the household implicit expenditure on it. While the utilization of durables occurs outside of traditional markets, we can still treat it as a fundamental economic activity in which households make periodic payments to themselves in order to maintain ownership of the goods. Although the services provided by these goods themselves cannot be directly traded, the goods can be bought and sold in the market. Therefore, when households choose to retain a functioning durable good instead of selling it, there is an associated opportunity cost. This opportunity cost can be seen as an implicit rental price, which can be determined by considering the price of the good and the forgone return from holding wealth in the form of the durable good. The user cost principle, introduced by Diewert (1974) and Jorgenson (1963), revolves around this concept and plays a central role in understanding the our measurement of the service flow.

Suppose a household purchases a durable good in period t and resells it to itself in the subsequent period. In that case, the implicit rental price of the good during period t

can be calculated as the purchase cost in period t minus the discounted resale value of the depreciated good in period $t+1$. Thus, we define the implicit rental price of the good as follows:

$$p_t = P_t - \frac{(1-\delta)P_{t+1}}{(1+r_t)} \tag{1.6}$$

where P_t is the spot price, $\delta \in (0,1)$ is the depreciation rate and r_t is a representative rate of return that measures the interest loss on holding the good throughout the period. It can be rewritten as

$$p_t = \frac{P_t(r_t + \delta(1+\pi_t) - \pi_t)}{(1+r_t)} \tag{1.7}$$

Where $\pi_t = (P_{t+1} - P_t)/P_t$ is the one period price inflation. The implicit expenditure on services flowing from the stock is then defined as $S_t = p_t D_t$, where D_t is the quantity of the consumer good currently owned by the household. If δ, π_t and P_t are exogenous, then

$$\frac{\partial p_t}{\partial r_t} = \frac{P_t\,(1+\pi_t)\,(1+\delta)}{(1+r_t)^2}$$

which is positive when $\pi_t \geq 0$. So, as the return rate increases, the implicit rental price of holding durables goes up. This translates into an increased relative implicit expenditure on the service flow. But

$$\frac{\partial^2 p_t}{\partial r_t^2} = -\frac{2P_t\,(1+\pi_t)\,(1+\delta)}{(1+r_t)^3}$$

which is negative when $\pi_t, r_t > 0$, and the increase in expenditure happens at diminishing rates. Therefore, the influence of r_t on p_t results in a pro-cyclical behavior, although the magnitude of price increases diminishes with the extent of the change in returns. Despite the significant volatility in realized expenditure on durable goods, the impact of p_t helps mitigate the level of volatility experienced in the implicit expenditure on the service flow. Consequently, the current implicit cost of the durable good holds greater relevance for the consumption process compared to its past acquisition cost. Similar applications of the user cost principle can be found in the works of Donovan (1978), Barnett (1978), and Barnett and Spindt (1982), focusing on financial and monetary assets.

We utilize this definition of expenditure on services derived from goods within the framework of the CCAPM. In a simplified model where households make consumption choices without distinguishing between different types of goods (i.e., the household utility function has a single argument), it becomes necessary to aggregate the services flowing from durable and nondurable goods appropriately. When $\delta = 1$ in equation (1.6), signifying a nondurable good, the price of the service flow equals the value of the stock (i.e., the spot price of the stock). The stock of the nondurable good is understood as the quantity acquired in period t. Conversely, for durable goods, the price of the service flow follows the general form described in equation (1.7). Various methods can be employed to define the stock of durables, and in this case, we adopt the declining balance method due to its application in constructing stock indexes for the national accounts. Therefore, the stock of the durable good D_t is

$$D_t = (1 - \delta)D_{t-1} + E_t$$

where E_t is the quantity acquired in period t. It is important to note that when we refer to nondurable consumption, we are also encompassing the consumption of traditional services. This is because, as per the definition used in national accounts, traditional services are nonstorable and fully depreciate each period. Hence, for our purposes, they are treated as the consumption of a nondurable good.

To aggregate the services flowing from both nondurable and durable goods, we adopt the approach proposed by Patterson (1992). Patterson constructs a divisia chain-type quantity index incorporating the user cost principle as established by Diewert (1974) and Jorgenson (1963). Simply put, the index takes the form of

$$Q_t = Q_{t-1} \prod_{i=1}^{n} \left(\frac{x_{i,t}}{x_{i,t-1}} \right)^{f_t(s_i)} \tag{1.8}$$

where $x_{i,t}$ is the quantity of the i-th consumer good, which is the end-period stock if the good is durable, or the quantity acquired in period t if the good is non-durable; $s_{i,t} = p_{i,t}x_{i,t} / \sum_{j=1}^{n} p_{i,j}x_{i,j}$ is the i-th expenditure share, where if the good is durable we take $p_{i,t}$ as the implicit rental price, and if the good is nondurable $p_{i,t}$ is the price of the good. Finally, $f_t(s_i) = 0.5(s_{i,t} + s_{i,t-1})$ states the weights of the index. Equation (1.8) defines a discrete time series for a index number which captures the aggregate change of an implicit comsumption measure which we refer to as *Consumption Services*.

In the upcoming chapter, we delve into the construction and application of this measure within a standard CCAPM framework featuring CRRA utility. The resulting model offers a new lens through which we can examine the role of durable goods in asset pricing. Indeed, our estimation of consumption betas underscores that, in order to fully capture their effects on household decision-making, a more nuanced approach to modeling durables is needed.

2 Data and Results

In this section, we provide a comprehensive explanation of the construction of the consumption services measure. As a benchmark, we compare it to other measures that have been developed in the field of asset pricing. These measures include the three-year consumption measure proposed by Parker and Julliard (2005), the fourth-quarter to fourth-quarter consumption measure introduced by Jagannathan and Wang (2007), and the unfiltered NIPA consumption measure presented by Kroencke (2017). Additionally, we consider the NIPA personal consumption expenditure measure, which is widely regarded as the "canonical" measure of consumption. Subsequently, we conduct empirical analysis to gain deeper insights into its implications for consumption risk.

It should be noted that the aforementioned measures only account for nondurable goods and services. Durables are not often addressed in the consumption measure; they are either phased out through additive separable utility or reduced to their stock. In contrast, Patterson's (1992) consumption services index, as described by Equation (1.8), is based on a detailed disaggregation of the stocks of and expenditure on all consumer goods. We could not replicate Patterson's (1992) series as we do not have access to the database used in the aforementioned paper. Our data was obtained from the National Income and Product Accounts (NIPA), produced by the Bureau of Economic Analysis of the United States. Thus, we disaggregate the consumption data to the extent possible within the framework of the National Accounts.

To build our measure, we mimic the structure of the Fixed Assets table and the Personal Income table in the NIPA. We define each consumer good as the minor types of products that comprise each major type of product in the respective account. For example, the Fixed Assets table divides data on consumer durables into four different major products: motor vehicles and parts, furnishings and durable household equipment, recreational goods and vehicles, and other durable goods. Each major product is then further divided into sub-components referred to as minor products. The major product "Other Durable Goods", for example, is divided into jewelry and watches, therapeutic appliances and equipment, educational books, luggage and similar personal items, and telephone and related communication equipment. These sub-categories represent the final level of disaggregation for nondurable and durable consumer goods. However, for services (which we treat as nondurable goods for the purposes of building the index), disaggregation goes further. Services are divided into two major types of products, with the first type further subdivided into seven minor types. Each of these minor types are also subdivided into further parts in some cases. Thus, for durable and nondurable goods, we consider each minor type of product as a consumer good. For services, we go two steps into the available level of disaggregation.

For the durable major type "Motor Vehicles and Parts" and the services major type "Final Consumption Expenditures of Nonprofit Institutions Serving Households", we make the choice of taking the major type itself as the consumer good[1]. The structure of the disaggregation is described in Tables 1, 2 and 3. Each entry presents a consumer goods, with its respective major type at the top of the column. The columns for "Motor Vehicles and Parts" and "Final Consumption Expenditures of Nonprofit Institutions Serving Households" are empty, indicating that we take the major type itself as the consumer good. In total, we have 49 consumer goods to be aggregated using Equation (1.8)

Durable Goods			
Motor Vehicles and Parts	**Furnishings and durable household equipment**	**Recreational goods and vehicles**	**Other Durable Goods**
	Furniture and furnishings	Video, audio, photographic, and information processing equipment and media	Jewelry and watches
	Household appliances	Sporting equipment, supplies, guns, and ammunition	Therapeutic appliances and equipment
	Glassware, tableware, and household utensils	Sports and recreational vehicles	Educational books
	Tools and equipment for house and garden	Recreational Books	Luggage and similar personal items
		Musical Instruments	Telephone and facsimile equipment

Table 1 – Types of Durable Goods

Nondurable Goods			
Food and beverages purchased for off-premises consumption	**Clothing and footwear**	**Gasoline and other energy goods**	**Other nondurable goods**
Food and nonalcoholic beverages purchased for off-premises consumption	Garments	Motor vehicle fuels, lubricants, and fluids	Pharmaceutical and other medical products
Alcoholic beverages purchased for off-premises consumptio	Other clothing materials and footwear	Fuel oil and other fuels	Recreational items
Food produced and consumed on farms			Household supplies
			Personal care products
			Tobacco
			Magazines, newspapers, and stationery

Table 2 – Types of Nondurable Goods

Our consumption data was sourced from the national accounts, specifically Tables 2.4.3, 2.4.4, 8.2, and 8.5. It's important to note that equations (1.8) and (1.7) require different information for each class of goods. For durables, we need data on prices and stock size, while for nondurables and services, we require information on prices and quantities acquired.

[1] We do this because there is no match between the Fixed Assets Table and the Personal Income Table for the former, and for the latter, the personal income table decomposes it into two minor types, one of which is deduced from the other.

Services			
Housing and utilities	**Health care**	**Transportation services**	**Recreation services**
Housing	Outpatient services	Motor vehicle services	Membership clubs, sports centers, parks, theaters, and museums
Household utilities	Hospital and nursing home services	Public transportation	Audio-video, photographic, and information processing equipment services
			Gambling
			Other recreational services
Financial services and insurance	**Other services**	**Final consumption expenditures of nonprofit institutions serving households**	**Food services and accommodations**
Financial services	Communication		Food services
Insurance	Education services		Accommodations
	Professional and other services		
	Personal care and clothing services		
	Social services and religious activities		
	Household maintenance		

Table 3 – Types of Services

To track the price changes of our 49 goods, we utilize Table 2.4.4, which provides price indexes for consumption expenditure for each type of good. Additionally, Table 2.3.4 offers a quantity index for personal consumption expenditure, allowing us to measure the quantity of nondurable goods and services acquired per period. Tables 8.2 and 8.5 provide us with a quantity index for the net stock of consumer durables and a quantity index for the depreciation of consumer durables, respectively. These indexes enable us to measure the stock and depreciation of consumer durables. It's worth noting that growth rates are preserved by index numbers. Therefore, they provide informative data regarding the growth rates utilized in Equation (1.8).

Finally, the Consumption Services measure is constructed at annual frequency due to the unavailability of quarterly data in the Fixed Assets table. The benchmark measures data is obtained from Kroencke's website. To ensure consistency, we will exclusively utilize Kroencke's annual series. Our dataset covers the period from 1961 to 2002, as this time frame resulted from the comprehensive data matching process conducted across all our sources. In addition to developing the Consumption Services measure (CS), we have further derived measures to analyze the Consumption Services of Nondurable Goods and Services (CS-N&S) and the Consumption Services of Durable Goods (CS-D). These series provide a more detailed perspective on consumption dynamics by allowing us to examine the impact of each class of goods individually.

Figure 1 illustrates the growth in consumption implied by various measures, including Consumption Services (CS), Consumption Services of Durable Goods (CS-D), Consumption Services of Nondurable Goods and Services (CS-N&S), the canonical measure (NIPA-N&S), three-year consumption (PJ-N&S), fourth-quarter to fourth-quarter consumption (Q4-N&S), and unfiltered consumption (UNFIL-N&S). The shaded areas in the figure indicate NBER recessions. Additionally, the graph presents the excess market return measured by the CRSP value-weighted market portfolio (MKTRF).

For further analysis, Tables 4 and 5 present the covariance and correlation matrices, respectively, for the same series depicted in Figure 1.

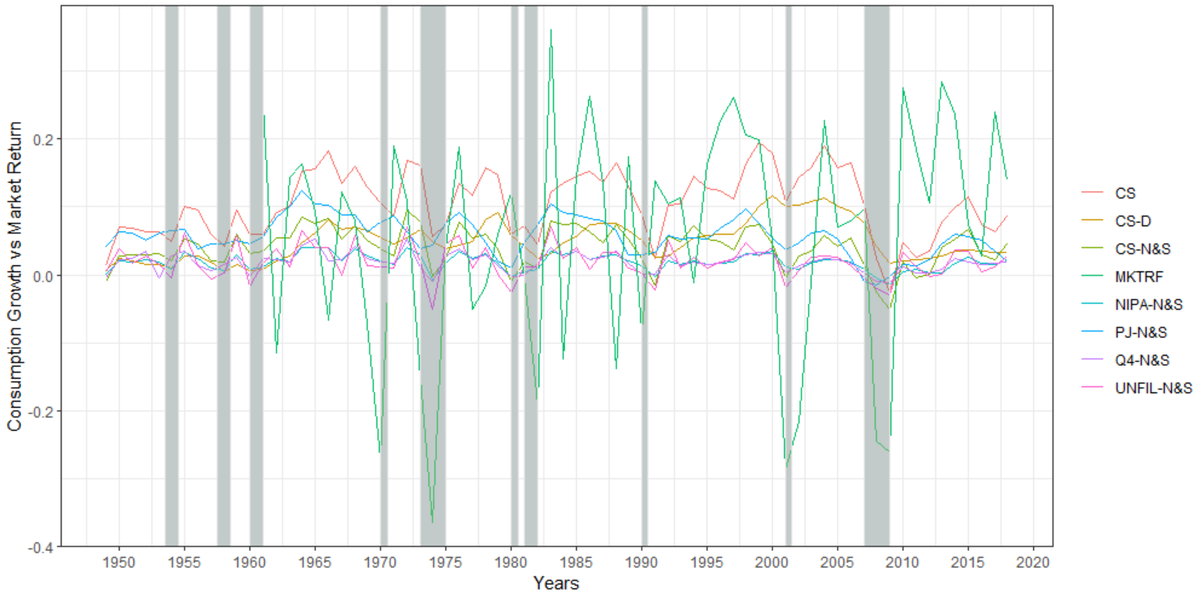

Figure 1 – Consumption vs Market Return

This figure plots the consumption growth implied by Consumption Services (CS), Consumption Services of Durables Goods (CS-D), Consumption Services of Nondurable Goods and Services (CS-N&S), the canonical measure (NIPA-N&S), three-year consumption (PJ-N&S), fourth-quarter to fourth-quarter consumption (Q4-N&S) and unfiltered consumption (UNFIL-N&S). Shaded areas are NBER recessions. It also shows the excess market return as measured by the CRSP value-weighted market portfolio (MKTRF).

Table 4 – Covariance Matrix (%)

For each consumption measure and the excess return on the CRSP value-weighted market portfolio (MKTRF) we calculate the pairwise sample covariance

$$s_{XY} = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{n-1} \times 100$$

where $X, Y = \{$MKTRF, CS, CS-N&D, CS-D, NIPA-N&S, PJ-N&S, Q4-N&S, UNFIL-N&S$\}$. MKTRF is the aforementiored CRSP porfolio, CS, CS-N&S and CS-D are respectively the full consumption services measure, the consumption services measure for nondurables and services and the consumption services measure for durable goods only. NIPA-N&S is the canonical consumption, NIPA personal consumption expenditure for nondurable goods and services. PJ-N&S is the three-year consumption. Q4-N&S is the fourth-quarter to fourth-quarter consumption and finally UNFIL-N&S is the unfiltered consumption. Notice that values are displayed as percentages (%). This is due to the fact that the raw sample covariance between consumption and excess returns tend to be numerically small.

	MKTRF	CS	CS-N&S	CS-D	NIPA-N&S	PJ-N&S	Q4-N&S	UNFIL-N&S
MKTRF	2.822	0.094	0.144	-0.066	0.054	0.129	0.098	0.171
CS	0.094	0.162	0.088	0.066	0.040	0.034	0.034	0.057
CS-N&S	0.144	0.088	0.076	0.007	0.030	0.042	0.030	0.056
CS-D	-0.066	0.066	0.007	0.057	0.008	-0.011	0.001	-0.002
NIPA-N&S	0.054	0.040	0.030	0.008	0.015	0.020	0.015	0.026
PJ-N&S	0.129	0.034	0.042	-0.011	0.020	0.067	0.024	0.041
Q4-N&S	0.098	0.034	0.030	0.001	0.015	0.024	0.020	0.032
UNFIL-N&S	0.171	0.057	0.056	-0.002	0.026	0.041	0.032	0.068

The data reveals that the growth of Consumption Services exhibits higher volatility compared to NIPA expenditure growth and other measures considered. However, this

Table 5 – Correlation Matrix

For each consumption measure and the excess return on the CRSP value-weighted market portfolio (MKTRF) we calculate the pairwise sample correlation

$$r_{XY} = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2}\sqrt{\sum_{i=1}^{n}(y_i - \bar{y})^2}}$$

where $X, Y = \{$MKTRF, CS, CS-N&D, CS-D, NIPA-N&S, PJ-N&S, Q4-N&S, UNFIL-N&S$\}$. MKTRF is the aforementiored CRSP porfolio, CS, CS-N&S and CS-D are respectively the full consumption services measure, the consumption services measure for nondurables and services and the consumption services measure for durable goods only. NIPA-N&S is the canonical consumption, NIPA personal consumption expenditure for nondurable goods and services. PJ-N&S is the three-year consumption. Q4-N&S is the fourth-quarter to fourth-quarter consumption and finally UNFIL-N&S is the unfiltered consumption

	MKTRF	CS	CS-N&S	CS-D	NIPA-N&S	PJ-N&S	Q4-N&S	UNFIL-N&S
MKTRF	1	0.139	0.312	-0.165	0.265	0.296	0.418	0.389
CS	0.139	1	0.798	0.687	0.818	0.322	0.602	0.547
CS-N&S	0.312	0.798	1	0.113	0.906	0.589	0.786	0.782
CS-D	-0.165	0.687	0.113	1	0.260	-0.180	0.044	-0.037
NIPA-N&S	0.265	0.818	0.906	0.260	1	0.628	0.861	0.840
PJ-N&S	0.296	0.322	0.589	-0.180	0.628	1	0.672	0.611
Q4-N&S	0.418	0.602	0.786	0.044	0.861	0.672	1	0.877
UNFIL-N&S	0.389	0.547	0.782	-0.037	0.840	0.611	0.877	1

higher volatility does not correspond to a stronger correlation with the market return. Tables 4 and 5 provide useful insights into this behavior.

First, it is important to note that the individual series for Consumption Services of Nondurable Goods and Services (CS-N&S) shows a high correlation with the canonical measure (0.9). Both of these series also demonstrate a similar, albeit small, correlation coefficient with the market return (0.3 and 0.2). This is expected, as CS-N&D only represents a different weighting of NIPA's consumption expenditure. The small correlation with the market return aligns with the notion that expenditure alone cannot explain excess returns.

In contrast, the second individual series, Consumption Services of Durable Goods (CS-D), exhibits negative covariance (and therefore, correlation) with market return. Additionally, it exhibits a weak correlation with its sister series, CS-N&S. As a result, each individual series contributes unique dynamics to the overall series (CS) that may not be present in the other. This partially explains why the correlation of CS with the market return is only half that of NIPA-N&D. The interplay between the service flow of durable goods and nondurable goods creates antagonistic dynamics that effectively contribute to the stabilization of aggregate consumption patterns.

This finding is intriguing as it presents a new perspective on the role of durable goods in hedging consumption. It challenges the prevailing understanding based on durable consumption models, thereby adding complexity to existing puzzles in the literature.

To further explore the implications within the framework provided by the CCAPM, we will utilize the model to estimate the associated risk of our measures. For this purpose, we select test assets from which we extract series for excess portfolio returns. As is customary in asset pricing, we will test consumption against the 25 size and book-to-market Fama-French portfolios, readily available at Kenneth French's website. Additionally, we will include the 8 currency portfolios proposed by Lustig and Verdelhan (2011) as test assets. This selection allows us to gain insight into how the results hold within currency markets.

The Fama-French 25 portfolios, introduced by Eugene Fama and Kenneth French, are a collection of stock portfolios extensively used in academic research on asset pricing (see Fama; French, 1993 and Fama; French, 1996). These portfolios are constructed by sorting stocks into groups based on their size and book-to-market (B/M) ratio. Specifically, they are divided into five size groups and five B/M groups. The size groups are determined by market equity (ME), calculated as the product of the stock price and the number of shares outstanding. The B/M groups, on the other hand, are based on the ratio of book equity to market equity. Combining these groups generates a total of 25 portfolios (5 size groups × 5 B/M groups).

In contrast, the 8 currency portfolios proposed byLustig and Verdelhan (2011) shift the focus from individual currencies to high versus low interest rate currencies, similar to how the Fama-French portfolios sort stocks based on size and B/M ratios to compare small/value versus large/growth stocks. At the end of each period, countries are assigned to eight portfolios based on the nominal interest rate differential. These portfolios are ranked from low to high interest rates, with portfolio 1 representing the lowest interest rate currencies and portfolio 8 representing the highest interest rate currencies.

2.1 Empirical Test

The series we have developed, along with our initial analysis, indicates that durable goods serve as a hedge against fluctuations in consumption. Therefore, compared to other consumption measures, the Consumption Services measure is expected to carry less risk. To test this hypothesis, we express the CCAPM (Consumption-based Capital Asset Pricing Model) in an expected return-beta format. That is,

$$E[R^e_{i,t+1}] = \beta_{i,t}\lambda_t, \tag{2.1}$$

where

$$\beta_{i,t} = \frac{\text{cov}_t[M_{t+1}, R^e_{i,t+1}]}{\text{var}_t[M_{t+1}]}, \tag{2.2}$$

and

$$\lambda_t = \frac{\text{var}_t[M_{t+1}]}{E_t[M_{t+1}]}. \tag{2.3}$$

For each asset, the expression $\beta_{i,t}$ represents the sensibility of returns $R_{i,t+1}$ to fluctuations in the stochastic discount factor M_{t+1}. In other words, it quantifies the direction and magnitude of the movements observed in $R^e_{i,t+1}$ in relation to the factors in M_{t+1}. Conversely, λ_t represents the market price of the risk premium, i.e., the compensation for bearing the market risk imposed by the uncertain payoffs.

We choose $M_{t+1} = \beta\left(\frac{C_{t+1}}{C_t}\right)^{-\gamma}$, which can be derived from CRRA preferences. Following Breeden, Gibbons and Litzenberger (1989), Savov (2011) and Jagannathan and Wang (2007), we consider the linear version of equation (2.1) given by

$$E[R^e_{i,t+1}] \approx \beta^c_{i,t}\lambda^c_t \tag{2.4}$$

where, for $g_{t+1} = \frac{C_{t+1}}{C_t}$

$$\beta^c_{i,t} = \frac{\text{cov}_t\left[g_{t+1}, R^e_{i,t+1}\right]}{\text{var}_t\left[g_{t+1}\right]} \tag{2.5}$$

and

$$\lambda_t^c \approx \gamma \frac{\text{var}_t\left[g_{t+1}\right]}{1 - \gamma E_t\left[g_{t+1} - 1\right]} \tag{2.6}$$

Thus, the term $\beta_{i,t}^c$ measures the standart CCAPM relationship between returns and consumption growth. If the asset value of the i-th asset tends to fall when consumption is also falling, $\beta_{i,t}^c$ will be high and positive. Similarly, if the asset value tends to move in opposite to consumption, it should be negative.

We now examine specification (2.4). Following the Fama and MacBeth (1973) procedure, we estimate consumption growth betas for each measure of consumption presented in the previous section. This is carried by performing the following time-series regression

$$R_{i,t}^e = \alpha_i + \beta_i^c g_t + \varepsilon_{i,t}$$

using the full sample of each asset's returns. As test assets we employ the Kenneth French's 25 portfolios Formed on Size and Book-to-Market and the 8 Lustig and Verdelhan (2011) currency portfolios. The risk free rate used to compute excess returns is the annualized secondary market rate for the 3-month treasury bill. Data for the portfolios comes from Kenneth French's website and from Lustig and Verdelhan (2011) replication package. Data for the risk-free rate comes from the database maintained by the research division of the Federal Reserve Bank of St. Louis (FRED). All data is taken at annual frequency and goes from 1961 to 2002.

Table 6 reports estimated betas while Figure 2 plot the same values for better visualization. It is clear from Figure 2 that the Consumption Services measure on average returns some of the smallest beta values. In fact, for the 25 portfolios Formed on Size and Book-to-Market, all of its beta estimates are slightly negative. This is due to the fact that the the consumption betas associated to the service flow from durable goods (CS-D) are relatively large (numerically) and negative. Conversily, the betas associated to nondurables (CS-N&S) follow a pattern similar to the canonical measure (NIPA-N&S). This is confirmed by the information displayed on Table 7, which computes mean consumption betas across all 33 portfolios. However, futher analysis of Table 6 and Figure 2 shows that the pattern observed on the fama-french portfolios does not translate well into the currency portfolios.

The estimated betas indicate that for equity markets, the risk associated with consumption is affected by households access to durable goods. Notably, the CS-D measure contradicts the beta pattern observed for other consumption measures. When considering measures for nondurable goods, beta values tend to increase as the B/M ratio (book-to-market ratio) increases across sizes (refer to Figure 2). This is logical since low B/M stocks, also known as growth stocks, offer higher potential returns and are therefore expected to carry greater risk. However, the estimated betas for the CS-D measure decrease as the B/M ratio increases (refer to Figure 2). This occurs because growth stocks (low B/M) are responsive to market conditions, whereas the service flow from durable goods increases when the market declines. As a result, the hedging effect of the service flow from durable goods is stronger against traditionally volatile and risky stocks.

Moreover, the estimated betas of CS, which consider both durable and nondurable goods, demonstrate a smoother pattern across B/M ratios compared to the benchmark measures. This smoothness can be attributed to the phenomena described in the preceding paragraph. By combining the contrasting levels of consumption risk indicated by the CS-N&D and CS-D measures, the disparity in consumption risk associated with growth and value (high B/M) stocks is reduced.

As alluded earlier, these results shed light on the limitations of the CCAPM when incorporating a service-based consumption measure that is not dependent on the inherently volatile nature of expenditure on durables. The correlation observed between this measure and market returns, along with the indication of estimated betas, implies that the overlooked risk factors contributing to financial puzzles may not necessarily be attributable to durable goods, as previous research suggests.

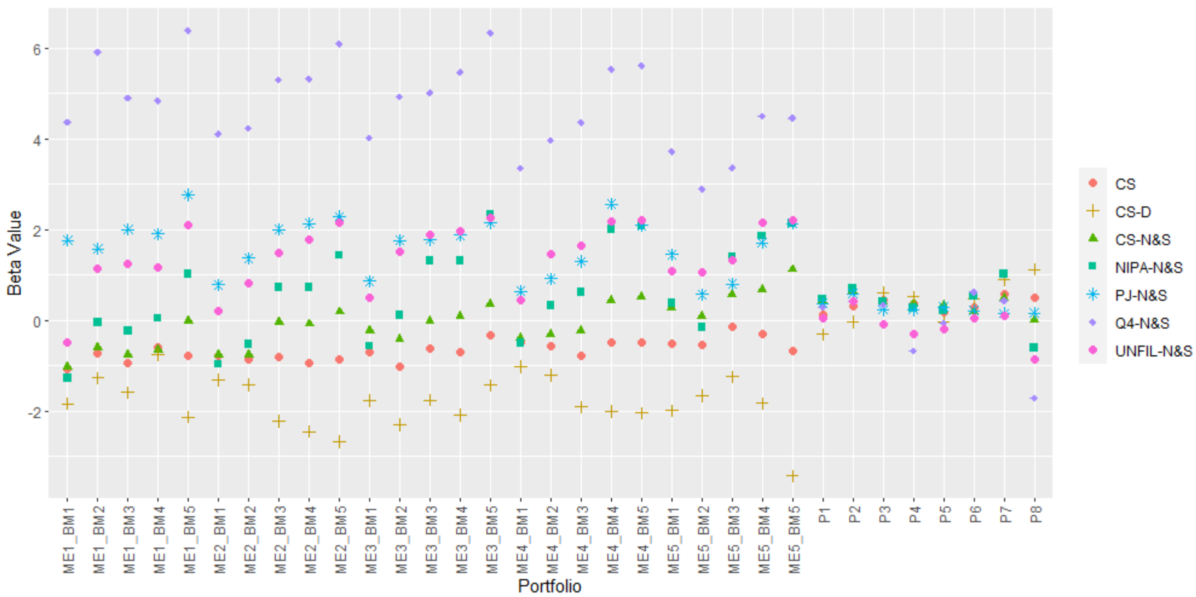

Figure 2 – Consumption Betas

Table 6 – Consumption Betas

For each consumption measure, we estimate 33 betas. CS, CS-N&S and CS-D are respectively the full consumption services measure, the consumption services measure for nondurables and services and the consumption services measure for durable goods only. NIPA-N&S is the canonical consumption, NIPA personal consumption expenditure for nondurable goods and services. PJ-N&S is the three-year consumption. Q4-N&S is the fourth-quarter to fourth-quarter consumption and finally UNFIL-N&S is the unfiltered consumption. Consumption betas are then estimated following the linear regression

$$R^e_{i,t} = \alpha_i + \beta^c_i g_t + \varepsilon_{i,t}$$

where excess returns $R^e_{i,t}$ are taken from Kenneth French's 25 portfolios formed on size and book-to-market and Lustig and Verdelhan (2011) 8 currency potfolios. The risk free rate used to compute excess returns is the annualized secondary market rate for the 3-month treasury bill.

	CS	CS-N&S	CS-D	NIPA-N&S	PJ-N&S	Q4-N&S	UNFIL-N&S
			SMALL FIRMS (ME 1Q)				
ME1 B/M1	-1.07	-1.02	-1.83	-1.27	1.76	4.37	-0.47
ME1 B/M2	-0.71	-0.61	-1.26	-0.04	1.58	5.9	1.13
ME1 B/M3	-0.93	-0.75	-1.58	-0.22	2	4.9	1.24
ME1 B/M4	-0.59	-0.65	-0.75	0.06	1.91	4.84	1.17
ME1 B/M5	-0.77	-0.01	-2.12	1.02	2.77	6.39	2.11
			MEDIUM FIRMS (ME 2Q)				
ME2 B/M1	-0.78	-0.75	-1.31	-0.97	0.79	4.12	0.22
ME2 B/M2	-0.86	-0.75	-1.42	-0.52	1.38	4.24	0.82
ME2 B/M3	-0.81	-0.04	-2.21	0.72	2.01	5.3	1.5
ME2 B/M4	-0.93	-0.08	-2.45	0.73	2.14	5.32	1.78
ME2 B/M5	-0.86	0.19	-2.67	1.44	2.29	6.09	2.16
			MEDIUM FIRMS (ME 3Q)				
ME3 B/M1	-0.7	-0.23	-1.77	-0.56	0.87	4.02	0.49
ME3 B/M2	-1.01	-0.42	-2.29	0.13	1.77	4.93	1.53
ME3 B/M3	-0.63	-0.01	-1.75	1.32	1.79	5.01	1.88
ME3 B/M4	-0.69	0.11	-2.08	1.32	1.88	5.47	1.97
ME3 B/M5	-0.32	0.37	-1.42	2.33	2.16	6.33	2.27
			MEDIUM FIRMS (ME 4Q)				
ME4 B/M1	-0.48	-0.38	-1.01	-0.49	0.65	3.35	0.46
ME4 B/M2	-0.55	-0.31	-1.21	0.34	0.92	3.97	1.46
ME4 B/M3	-0.78	-0.23	-1.9	0.62	1.3	4.36	1.66
ME4 B/M4	-0.47	0.45	-2	2.02	2.57	5.53	2.19
ME4 B/M5	-0.47	0.53	-2.04	2.09	2.1	5.61	2.2
			BIG FIRMS (ME 5Q)				
ME5 B/M1	-0.52	0.28	-1.99	0.39	1.45	3.72	1.09
ME5 B/M2	-0.53	0.09	-1.65	-0.15	0.57	2.9	1.05
ME5 B/M3	-0.14	0.57	-1.24	1.39	0.81	3.37	1.34
ME5 B/M4	-0.3	0.68	-1.82	1.86	1.71	4.5	2.16
ME5 B/M5	-0.67	1.12	-3.42	2.13	2.14	4.46	2.21
			CURRENCY PORTFOLIOS				
P1	0.14	0.44	-0.3	0.48	0.38	0.29	0.06
P2	0.33	0.66	-0.02	0.7	0.59	0.43	0.42
P3	0.46	0.41	0.61	0.43	0.24	0.34	-0.09
P4	0.38	0.37	0.52	0.28	0.23	-0.67	-0.29
P5	0.19	0.34	-0.04	0.23	0.3	-0.06	-0.18
P6	0.3	0.19	0.49	0.55	0.22	0.63	0.06
P7	0.58	0.5	0.9	1.02	0.16	0.43	0.1
P8	0.49	0.01	1.13	-0.6	0.16	-1.71	-0.86

Table 7 – Mean Consumption Betas

For each consumption measure, we estimate 33 betas on the following time series regression

$$R^e_{i,t} = \alpha_i + \beta^c_i g_t + \varepsilon_{i,t}$$

this table computes the mean value, standart deviation, minimum and maximum values of estimated betas. Consumption growth is calculated from each of the consumption measures identified on the first column of the table. Excess returns $R^e_{i,t}$ are taken from Kenneth French's 25 portfolios formed on size and book-to-market and Lustig and Verdelhan (2011) 8 currency potfolios.

Measure	N	Mean Beta	St. Dev.	Min	Max
CS	33	-0.415	0.492	−1.071	0.580
CS-N&S	33	0.033	0.506	−1.022	1.124
CS-D	33	-1.269	1.109	−3.423	1.129
NIPA-N&S	33	0.569	0.930	−1.270	2.329
PJ-N&S	33	1.321	0.797	0.162	2.772
Q4-N&S	33	3.597	2.274	−1.707	6.390
UNFIL-N&S	33	1.056	0.927	−0.863	2.270

Conclusion

This study aims to investigate role of the service flow from durable goods on asset pricing. Following Patterson (1992), we construct an aggregate consumption measure based on the "user cost principle" introduced by Jorgenson (1963) and Diewert (1974). Unlike the conventional approach that assumes a technology capable of converting goods into service flows, the user cost approach attempts to directly captures those services thorough the implicit expenditure realized by households. This implicit expenditure occurs when households choose to continue holding the durable good each period.

By analyzing estimated betas, we uncover interesting insights into the relationship between durable goods and risk. Our measure consistently demonstrates smaller beta values when compared to benchmark measures. This is particularly noticeable in the 25 portfolios formed based on Size and Book-to-Market ratios, where all beta estimates are slightly negative. This outcome primarily stems from the relatively large and negative consumption betas associated with the service flow from durable goods. In contrast, the betas linked to the service flow from nondurables exhibit a pattern similar to NIPA expenditure. These observations are supported by the mean consumption betas calculated across all 33 portfolios. However, it's important to note that the pattern observed in our sample of portfolios does not hold true for currency portfolios, suggesting that consumption risk is influenced differently in these two contexts.

Our findings indicate that the utilization of Service Flow from durable goods can effectively help households reduce consumption risk and hedge their consumption. While our initial analysis may not provide definitive conclusions, its straightforward approach sheds light on an overlooked aspect in the existing literature. Further research is crucial to evaluate this measure against more advanced versions of the CCAPM. For instance, developing a model that incorporates household heterogeneity in the size of the durable goods stock would allow for a more conclusive verification of consumption hedging behavior.

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