INTERTEMPORAL SUBSTITUTION IN CONSUMPTION: A LITERATURE REVIEW

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Abstract. This paper reviews the status quo of the empirical literature about the elasticity of intertemporal substitution (EIS) in consumption. Aiming to answer the question what the true magnitude of the parameter really is, it discusses several recent advances of the theory and highlights challenges for the estimation. Although the general discussion still seems to be prevailed by Hall’s early EIS estimates close to zero, we show that several deviations from the time-additive constant relative risk aversion model speak in favor of considerably higher values. Our treatment is supposed to provide researchers a hint at which parameter is a reasonable and incontrovertible choice for the calibration of models in macroeconomics and finance.

Keywords. Consumption; Intertemporal substitution; literature review

1. Introduction

The elasticity of intertemporal substitution (EIS) in consumption is a central parameter in models of dynamic choice in macroeconomics and finance. Intuitively, it characterizes a consumer’s willingness to pre- or postpone consumption in response to changes in investment opportunities. A consumer who saves more if interest rates are high is characterized by a high EIS. More formally, the EIS is defined as the negative ratio of changes in log consumption growth and log growth of marginal utility of consumption, that is,

\[ EIS = -\frac{\partial \log \left( \frac{C_{t+1}}{C_t} \right)}{\partial \log \left( \frac{\partial U/\partial C_t}{\partial U/\partial C_{t+1}} \right)} \]  

(1)

where \( U \) represents the utility function of the consumer. In common dynamic choice models, the denominator is closely linked to real interest rates.

Higher interest rates increase the overall wealth of the consumer due to higher cash-flows in future periods. The effect that consumers spend a part of this higher future income already today is called “income effect” or “wealth effect.” On the other hand, with higher interest rates a smaller fraction of today’s consumption has to be saved in order to have an additional unit of consumption tomorrow. This motive to save more today and postpone today’s consumption is called the “substitution effect.” Consumers with a high EIS are more willing to substitute consumption over time, which has a direct impact on the substitution effect.

This intuition is made explicit in macroeconomic models: The intertemporal IS relation relates current and expected future interest rates with current aggregate demand (see Woodford (2003)). Models of tax policy imply that a high EIS leads to more severe welfare gains or losses in case of a change in the tax rate (see King and Rebelo (1990)) or the tax system (see Jones et al. (1993)). Kydland and Prescott (1982) and Jones et al. (2000) set up equilibrium business cycle models and argue that an EIS between 0.8 and 1

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gives the best fit to the data. Lucas (1990) considers the consumption Euler equation under certainty that relates interest rates \( r_f \) with a consumer’s time discount rate \( \delta \) and consumption growth via

\[
r_{f,t} = \delta + \text{EIS}^{-1} \log(C_{t+1}/C_t)
\]

and, based on average consumption and interest rates in the United States, rules out an EIS below 0.5.\(^1\) Other studies, first and foremost the widely recognized paper of Hall (1988), run regressions based on the above equation to study the link between the time series of consumption growth and interest rates. Hall (1988) concludes that “all estimates [of the EIS] are small. Most of them are quite precise, supporting the strong conclusion that the elasticity is unlikely to be much above 0.1, and may well be zero.” Although follow-up papers came up with mixed results, the assumption of an EIS close to or above 1 to calibrate economic models has seemed questionable since then.

More recently, the introduction of long-run risks asset pricing models by Bansal and Yaron (2004) raised hope to have the potential to solve various asset pricing puzzles such as the equity premium puzzle. Apart from that, the model is famous for its tractability and the clear intuition it provides. A key assumption is an EIS above 1, which leads to cyclicality of price dividend ratios, a low and smooth risk-free rate, and a sizeable equity premium. Standard choices in the long-run risks literature are 1.5 or 2 (see, e.g., Bansal and Yaron (2004), Ai (2010), and Drechsler and Yaron (2011)), which is at odds with large parts of the early literature outlined above.

Based on the status quo of the empirical literature about intertemporal substitution in consumption, this paper aims to give the best possible answer to the question:

(A) What is the true value of the EIS?

For that purpose it reviews studies that provide estimates of the parameter. Due to the long list of choices a researcher has to make when estimating the EIS, differences in the study design emerge, for example, with respect to sample period, geographical origin of the data, proxies for consumption and returns, assumptions on liquidity constraints or stock market participation. The most important and most interesting criterion from an economic point of view is the consumer’s utility function. We find that moving away from the time-additive CRRA model considered in the early literature often results in EIS estimates around or above one. Conditional on the respective decision model, we aim to answer the question:

(B) Can question (A) ever be answered properly?

If it is simply impossible to give an exhaustive answer on question (A), which conclusion can we draw for future research in this field? Finally, this paper aims to give researchers a hint at how to answer the question:

(C) What is a reasonable choice of the EIS in representative agent models?

The paper is structured as follows: In Section 2 we review prominent decision models and EIS estimates based on macro data given the respective decision models. We discuss in the following order: Recursive preferences in Section 2.1, the time-additive CRRA model as a special case in Section 2.2, habit formation in Section 2.3, and multiple consumption goods in Section 2.4. Section 3 reviews evidence based on microdata. We discuss further interesting aspects which do not alter the “big picture” in Section 4. After the extensive literature review in Sections 2 to 4, we give profound answers on questions (A), (B), and (C) in Section 5, which concludes the paper.

2. Consumers’ Preferences and the EIS

As we will show in this section, assumptions on consumers’ preferences have a great impact on estimates of the EIS. We start with reviewing the most prominent preference representations.

Let \( C' = (C_t)_{t \geq 1} \) denote a consumption plan. \( C_t \) denotes time \( t \) consumption of a single good, which serves as the numeraire. We follow a large part of the literature and assume discrete time, although the theory can easily be developed in continuous time as well. Depending on the consumer’s preferences, the
maximization of lifetime utility requires smoothing of consumption inter-temporally, that is, across time and intratemporally (within a single period), that is, across states. In general, both concepts can be treated separately. Kreps and Porteus (1978), Epstein and Zin (1989), and Weil (1990) propose an intertemporal utility theory that expresses time utility $U(C_t)$ of a consumption plan $C_t$ as a function of time consumption $C_t$ and utility $U(C_{t+1})$ of the consumption plan starting at $t+1$. This approach is hence called recursive utility. A prominent example of such a function is the constant elasticity of substitution (CES) aggregator

$$U(C_t) = \left[ (1 - e^{-\delta})C_t^{1-\psi} + e^{-\delta} \left\{ u^{-1} \left( \mathbb{E}_t \left[ u(U(C_{t+1})) \right] \right) \right\} \right]^{\frac{1}{1-\psi}} \tag{2}$$

where $u$ is an intratemporal utility function as described below and $\delta$ is the consumer’s subjective time discount rate. The (constant) elasticity parameter $\psi$ is the consumer’s EIS as can easily be shown by differentiation of Equation (2) and introducing the result in Equation (1).

To evaluate a single random amount $x_t$ in period $t$ it is assumed that the consumer uses a felicity function (also called intratemporal or within-period utility function) $u : \mathbb{R} \rightarrow \mathbb{R}$, which is supposed to be increasing and—as long as the consumer is risk-averse—concave. The most prominent example is the CRRA or iso-elastic felicity function

$$u(x_t) = \begin{cases} x_t^{1-\gamma} & \text{if } \gamma \neq 1 \text{ and } u(x_t) = \log(x_t), \text{ if } \gamma = 1 \end{cases} \tag{3}$$

$\gamma$ is the Arrow-Pratt measure of relative risk aversion (RRA). The resulting utility function $U$ is intertemporally homothetic, which means that rich consumers (i.e., those with a high level of consumption) and poor consumers have equal preferences regarding proportional variations in consumption streams. On the one hand, the higher the consumer’s risk aversion parameter $\gamma$, the stronger is her need to smooth consumption over states. On the other hand, the greater the consumer’s EIS $\psi$, the weaker is her need to smooth consumption over time.

A prominent special case is encountered when setting $\psi = \gamma^{-1}$, that is, when imposing a tight link between the consumer’s willingness to substitute consumption over states and over time. In this case, Equation (2) is a monotonous transformation of

$$U(C_t) = \mathbb{E}_t \left[ \sum_{\tau=t}^{\infty} e^{-\delta(\tau-t)} u(C_{\tau}) \right] \tag{4}$$

and hence yields the same implications for choice. This specification is called time-additive CRRA utility and can be generalized to other felicity functions $u$.

In contrast to the general specification, the time-additive CRRA utility function is time-separable, which intuitively means that past consumption does not influence preferences about future consumption. This feature, as well as intertemporal homotheticity, might get lost when other felicity functions are considered in the time-additive framework, such as functions including reference points that depend on past consumption as in the case of habit formation. We discuss this model in detail in Section 2.3. Felicity functions that allow for multiple consumption goods are discussed in Section 2.4.

It is instructive to look at the consumption-savings decision of a consumer in the context of the most simplistic time-additive CRRA model. A consumption plan is optimal if it is not worthwhile to invest a fraction of current consumption $C_t$ in an asset with gross return $R_{t+1}$ to profit from a higher consumption $C_{t+1}$ in the next period. This intuition corresponds to the first-order condition given by the Euler equation

$$\frac{\partial U(C_t)}{\partial C_t} = u'(C_t) = \mathbb{E}_t \left[ e^{-\delta} u'(C_{t+1}) R_{t+1} \right] \tag{5}$$
Here, $R_{t+1}$ denotes the real return on an arbitrary asset. If this return is risk-free, it can be separated from the expectations operator, that is, $R_{f,t+1} = e^{\delta u'(C_t)} / \mathbb{E}_t[u'(C_{t+1})]$, since it is time $t$-measurable. The continuously compounded risk-free return $r_{f,t}$ is then given by
\[
r_{f,t} = \log(R_{f,t+1}) = \delta - \log \left( \frac{\mathbb{E}_t[u'(C_{t+1})]}{u'(C_t)} \right)
\]
This term is exactly equal to $-\log(\partial U / \partial C_t)$ which, in combination with Equation (1), explains why the EIS is often referred to as the ratio of changes in log consumption growth and the log interest rate. Moreover, it yields
\[
1 = \mathbb{E}_t \left[ e^{-\delta \left( \frac{C_{t+1}}{C_t} \right)^{-\psi}} R_{t+1} \right]
\]
which is often referred to as the consumption Euler equation. In contrast to the Euler equation given by (5), it is stationary and thus suited for estimations of the parameters $\delta$ and $\psi$.

Dropping the restriction $\psi = \gamma^{-1}$, Epstein and Zin (1989) show that recursive preferences lead to the following Euler equation:
\[
1 = \mathbb{E}_t \left[ e^{-\delta \theta \left( \frac{C_{t+1}}{C_t} \right)^{-\psi}} R_{w,t+1} R_{t+1} \right]
\]
where $\theta = \frac{1-\gamma}{1-\psi}$ and $R_w$ denotes the return on the wealth portfolio that pays aggregate consumption as dividends and is not observable. In the following, we review papers that utilize this Euler equation or its logarithmic version to estimate the structural parameters of the model, especially the EIS. The special case of time-additive preferences is discussed in a further subsection, before we deal with further felicity functions in a time-additive context. In particular, we discuss habit formation and multiple consumption goods.

2.1 Recursive Preferences

To estimate the EIS from Equation (7), researchers usually use log growth in aggregate expenditures on nondurables and services taken from National Income and Product Accounts (NIPA)-tables of the U.S. Bureau of Economic Analysis (BEA) for $C_{t+1}/C_t$ and a 3-month Treasury bill rate adjusted by inflation for $R_{t+1}$.\(^3\) The major obstacle is however the nonobservability of the return $R_w$ on the wealth portfolio. We discuss two approaches to overcome this problem. The first is to make certain assumptions on the structure of the wealth portfolio or on its return and to run estimations based on those assumptions (see Sections 2.1.1 and 2.1.2). The second is to specify dynamics of growth in consumption or a production technology and solve an equilibrium model. This would usually yield a representation of the return on wealth in terms of the model’s parameters and state variables. The EIS can then be estimated jointly with other preference parameters and the structural parameters of the model (see Section 2.1.3). We discuss implications of such models for timing premia in Section 2.1.4.

2.1.1 Approximation of the Return on Wealth

The wealth portfolio contains all kinds of assets that generate real payments in the future, especially human capital and other nontradable “investments.” A rather elegant approach is chosen by Lybbert and McPeak (2012) who estimate preference parameters of the recursive model from data of Kenyan herders whose wealth is assumed to solely consist of the current values of their herds, which implies that the wealth portfolio and the only reasonable test asset are given by the herds themselves. They consistently
define consumption as “herd off-take in form of sales, slaughter, transfers out of herd, and total milk produced by herd.” Their EIS estimates for two different areas in Kenya are 0.66 and 3.27. Although the results of Lybbert and McPeak (2012) are provided in a methodologically sound way, they are only meant to describe the intertemporal consumption behavior of a special group of consumers. The transferability of the results to consumers who have access to financial markets and whose personal wealth stems from several sources is rather questionable.

Epstein and Zin (1991) use a broad stock market index as proxy for the wealth portfolio. They furthermore use the original Euler Equation (7) as moment condition and estimate the model parameters with the generalized method of moments (GMM). Depending on sample and instrument sets, they estimate an EIS between 0.17 and 0.86 and an RRA coefficient around 1. These results speak in favor of a preference for late resolution of uncertainty. The idea of using a broad stock market index as proxy in a nonlinear environment is followed by Kim and Ryou (2012), Stock and Wright (2000), Weber (2000), and Yogo (2006). EIS estimates in these studies vary from negative values (Stock and Wright (2000)) to values clearly above 1 (Kim and Ryou (2012)). Most estimates are rather imprecise.

All these results have to be interpreted with care. A stock market index might be a rather poor approximation of the wealth portfolio. Critique of that approach goes back to Roll (1977) for the classic CAPM and is prolonged by Ludvigson (2012) and Lustig et al. (2013) for consumption-based asset pricing models with recursive preferences. The latter estimate the fraction of human capital in total wealth at 90%. They conclude that “the stand-in households” portfolio is much less risky than one would conclude from studying the equity component of that portfolio.” Bansal et al. (2010) conduct a simulation study in which they analyze the consequences of incorrectly using the return on the stock market portfolio instead of the true wealth portfolio to estimate Euler equations. Due to the high volatility of stock returns, the estimated preference parameters are biased and the (correctly specified) model is rejected based on the model’s overidentifying restrictions.

Thimme and Völkert (2015) construct a proxy that contains human capital from the variable cay as introduced by Lettau and Ludvigson (2001) and show that it is much less volatile than the return on a stock market index. The authors assume that human capital is proportional to labor income, an assumption which is rather established in the literature (see, e.g., Jagannathan and Wang (1996)), although criticized by Lustig et al. (2013). They estimate an EIS of 1.78 and an RRA coefficient of around 28, albeit with large standard errors for both parameters. Gomes et al. (2009) construct a wealth proxy from durable goods and private residential fixed assets and estimate the parameters more precisely. They find an EIS of 0.6 and an RRA coefficient of 16.

Chen et al. (2013) use an alternative formulation of Euler Equation (7), which relies on the consumer’s continuation value and makes a consideration of a wealth proxy obsolete. They assume that the ratio of continuation value and current consumption is a function of certain state variables and estimate it with a semiparametric approach. They estimate an EIS between 1.67 and 2 (significantly above 1) and a risk aversion coefficient around 60.

The estimation of preference parameters within a recursive framework is still difficult due to the latency of the return on wealth. The majority of studies that use sophisticated approximations of this return finds estimates above one. However, the plausibility of these estimates depends on the plausibility of the proxies, which is difficult to test. More research about the wealth portfolio is necessary to enable more compelling conclusions.

2.1.2 Substituting Consumption by Returns or Vice Versa

Campbell (1993) allows a new perspective on the Euler equation in the recursive model that circumvents the necessity of specifying the return on the wealth portfolio. Given that consumption and returns on all considered assets are jointly lognormal and homoskedastic, Equation (7) can be written in the following...
log-linearized form:

\[ 0 = -\delta \theta - \frac{\theta}{\psi} E_t[\Delta c_{t+1}] + (\theta - 1) E_t[r_{w,t+1}] + E_t[r_{i,t+1}] + \frac{1}{2} \sigma_r^2 \]  

(8)

where \( \Delta c_{t+1} = \log(\frac{C_{t+1}}{C_t}) \) denotes log consumption growth, \( r_w = \log(R_w) \) denotes the log return on wealth and \( \sigma_t \) is the (assumed constant) volatility of \( \frac{\theta}{\psi} \Delta c_{t+1} + (\theta - 1)r_{w,t+1} + r_{i,t+1} \). Introducing \( r_{i,t+1} \) itself for \( r_{w,t+1} \) gives the simple representation

\[ E_t[r_{w,t+1}] = \text{const} + \frac{1}{\psi} E_t[\Delta c_{t+1}] \]  

(9)

Reintroducing this in Equation (8) gives

\[ E_t[\Delta c_{t+1}] = \text{const} + \psi E_t[r_{i,t+1}] + \epsilon_{t+1} \]  

(10)

where \( \epsilon_{t+1} \) is a shock or surprise, that is, an unconditionally zero mean deviation from the expectation that could not be foreseen with information available at time \( t \). Attanasio and Weber (1989) and Yogo (2004) run regressions based on Equation (10), using the risk-free return as a test asset and estimate values of 2 and 0.2 for the EIS. Attanasio and Weber (1989) furthermore estimate RRA around 5 and, thus, \( \gamma > \psi^{-1} \), which Epstein and Zin (1989) interpret as a preference for early resolution of uncertainty. Ortu et al. (2013) pursue a similar approach but decompose consumption growth and interest rate in several components, which exhibit different levels of persistence. Running regression (10) separately for the different components, they estimate an EIS of 2.09 based on a sample that starts in 1930, and 5.54 based on a postwar subsample. They argue that “using disaggregated consumption data is key to finding a value for the [EIS] greater than one.”

Instead of considering the return on wealth \( R_{w,t+1} \) in the Euler equation, another idea is to use aggregate wealth \( W_t \) directly, or the consumption-to-wealth ratio \( C_t/W_t \) which is assumed to be stationary. While Thimme and Völkert (2015) use a proxy of the ratio to come up with a return proxy, Campbell (1993) suggests a more direct approach. Following Campbell and Shiller (1988), the consumer’s budget constraint

\[ W_{t+1} = R_{w,t+1}(W_t - C_t) \]  

can be solved for \( R_{w,t+1} \) and log-linearized, which gives the approximate identity

\[ r_{w,t+1} = \kappa_0 - \kappa_1(c_{t+1} - w_{t+1}) + (c_t - w_t) + \Delta c_{t+1} \]  

(11)

with log consumption-to-wealth ratio \( c - w \) and constants \( \kappa_0 \) and \( \kappa_1 \), where \( \kappa_1 \) is the steady state of \((W_t - C_t)/W_t \). This equation can be solved forward to yield

\[ c_t - w_t = \text{const} + \sum_{j=1}^{\infty} \kappa_j^1(r_{w,t+j} - \Delta c_{t+j}) \]  

(12)

This identity holds \textit{ex post}, but also \textit{ex ante}, if we introduce an expectations-operator on the right-hand side.

Equation (12) is empirically investigated by Lettau and Ludvigson (2001) who assume that asset holdings and human capital sum up to total wealth and that human capital is proportional to aggregate labor income. Given these assumptions and Equation (12), log consumption \( c_t \), log asset holdings \( a_t \), and log labor income \( y_t \) must be cointegrated. The empirical cointegration residual \( cay \) is supposed to quantify innovations in the log consumption-to-wealth ratio. Lettau and Ludvigson (2001) show that a high \( cay \) predicts high future returns in the following periods while \( cay \) has little power in explaining future consumption growth. \( cay \) has since then been used as a return predictor by numerous empirical asset pricing studies.

Equation (12) is an accounting identity, that is it can be derived without making any assumptions on the consumer’s preferences. Campbell (1993) suggests to introduce the return approximation (9) into

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Equation (12) to substitute consumption growth. This gives

\[ c_t - w_t = \text{const} + (1 - \psi) \mathbb{E}_t \left[ \sum_{j=1}^{\infty} \kappa_j^t r_{w,t+1} \right] \]  \hspace{1cm} (13)

In light of this equation, the very established positive coefficient of \( cay \) in predictive regressions can be interpreted as an indication that the EIS must be below 1. As pointed out by Favero (2005), the trade-off between wealth effect and substitution effect, described in the introduction, becomes apparent in this equation. If returns are expected to be high in the future, a consumer with an EIS above 1 consumes a smaller fraction of his wealth today and saves more for future consumption, that means the substitution effect dominates the wealth effect. With an EIS below 1, the consumer is not willing to postpone consumption in order to consume relatively more tomorrow, that means the wealth effect dominates the substitution effect and a larger fraction of the consumer’s wealth is already consumed today. Qualitatively, this seems in line with the empirical asset pricing literature.

Favero (2005) carefully analyzes Equation (13) quantitatively using \( cay \) and a VAR to calculate return expectations at time \( t \). He uses the return on the S&P500 index as a proxy for the return on wealth in the VAR which may be problematic as mentioned in Section 2.1.1. The estimated EIS is 0.85 with a standard error of only 0.03, that means the EIS is clearly above 0 and below 1.

All results discussed in this section, especially the relation between the coefficient of \( cay \) in predictive regressions and the EIS, depend on the plausibility of the strong relation between the expected return on wealth and expected consumption growth as expressed in Equation (9). The procedure in Favero (2005), that is eventually approximating expected consumption growth with expected stock returns, seems at least questionable. For the identity (12) to hold, one should use a consistent definition of the return on wealth, that is one that includes the return on human capital. Using a consistent measure, such as the one considered by Thimme and Völkert (2015), would however make the analysis redundant.

The link between expected consumption growth and expected return might be less pronounced than assumed here. It might for example be a too strong assumption that returns and consumption growth are jointly lognormal. Maybe even more apparent, the assumption of homoskedasticity might fail. For example, time-varying volatility is a key feature in the long-run risks framework as it disentangles the return on wealth from consumption growth, which enables the solution of several asset pricing puzzles. We discuss these models next in Section 2.1.3.

2.1.3 Estimation of Pure Exchange Economy Models

The interest in recursive preferences was amplified by the introduction of long-run-risks asset pricing models by Bansal and Yaron (2004). The authors assume that consumption and dividend growth are lognormal with a time-varying growth rate, which evolves as a persistent AR(1) process. In the heteroskedastic version of the model, the authors moreover assume that the variances of consumption and dividend growth are time-varying but highly persistent and hence predictable. Bansal and Yaron (2004) show that consumers with time-additive CRRA preferences do not claim a compensation for taking these long-run risks, while a recursive utility consumer with an EIS above one claims a sizeable equity premium even if her RRA coefficient is rather low. Apart from the equity premium puzzle, the model and a large number of extensions introduced in follow-up papers show potential to explain several further asset pricing puzzles. This makes the long-run risks framework and, hence, recursive preferences a promising choice.

Specification of consumption and dividend growth dynamics and the evolution of state variables yield a representation of Euler equations in terms of the structural parameters of the model and the state variables. Estimations of the full parameter set of such a model hence do not require an approximation of the wealth portfolio. It does, however, by definition rely on assumptions about the relation between the return on
wealth and consumption and dividend dynamics. We now discuss papers that estimate the parameters of the long-run risks model and some extensions, with special focus on the preference parameters. Of course, the results of these parametric estimations have to be interpreted with care. Drawing conclusions about the magnitude of the EIS from the estimates reported in this section requires that the model and the mechanisms through, which it generates implied asset pricing moments are a close approximation of the mechanisms that lead to empirical moments in the data.

The great obstacle for the estimation of these models lies in the latency of the state variables. A simple approach to recover time series of the state variables in the heteroskedastic version of the Bansal and Yaron (2004) model is introduced by Constantinides and Ghosh (2012) who take advantage of the fact that the model-implied log price dividend ratio and the risk-free interest rate are affine functions of the state variables. They invert these equations and estimate the model with GMM. Depending on the weighting matrix and the utilized test assets, the estimated EIS is between 1.16 and 1.84, with large standard errors, however. Avramov and Cederburg (2012) use the same method to come up with time-series of the state variables and use them, in combination with cash-flow and asset pricing quantities, to estimate a VAR model with maximum likelihood, which allows conclusions about the parameters of the long-run risks model. They estimate a quiet large EIS of 4.5 but do not report standard errors.

A related approach is chosen by Bansal et al. (2010) who use the projection of consumption growth on a set of observable predictor variables as trend consumption growth and the squared deviation from that trend, projected on the same set of predictor variables as variance. Their GMM estimation based on annual data yields an EIS between 0.4 and 0.5. Through a simulation study, they however show that time aggregation of consumption and return data lead to a severe downward bias in EIS estimates in small samples. For the simulation, they assume a monthly decision interval and an EIS of 2 and re-estimate an EIS below 1 based on aggregated data. To avoid biased parameter estimates, the authors furthermore use the Simulated Method of Moments (SMM) approach, that is, indirect inference. This approach identifies model parameters that minimize (a function of) the distance between model-implied moments, generated by simulation, and empirical moments. Since the method relies on simulations it allows the researcher to choose an arbitrary decision interval. With this approach they estimate an EIS of 2.43 with a standard error of 1.3.

Closely related, Hasseltoft (2012) estimates the heteroskedastic version of the long run risks model with SMM and finds an EIS of 2.51 with a standard error of 0.74. Theocharides and Paseka (2010) estimate the homoskedastic version of the model with a Bayesian Monte Carlo Markov Chain (MCMC) approach. They find an EIS of 3.2 based on a 1934–2005 sample and 1.62 based on a postwar sample.

Eraker et al. (2012) extend the homoskedastic model by durable goods and inflation. Based on the Bayesian MCMC method, they estimate an EIS of 2.39. Colacito and Croce (2011) generalize the homoskedastic model to a two-country model. This model implies that innovations in the exchange rates between two countries are given by the difference of the log pricing kernels, which yields additional moment conditions that the authors rely on to estimate the model parameters. They use a projection approach similar to Bansal et al. (2010) to come up with time-series of the state variables and estimate model parameters with GMM, especially an EIS around 2. Bansal and Shaliastovich (2013) extend the model of Colacito and Croce (2011) by inflation and heteroskedasticity in trend growth of consumption and inflation. They estimate the model with maximum likelihood and find an EIS of 1.81.

The long-run risks model requires an EIS above 1 to generate a sizeable equity premium, a low and smooth risk-free rate, and a cyclical price dividend ratio. In line with that, all studies reviewed in this section report EIS estimates above 1. The plausibility of these estimates comes along with the plausibility of the assumed model dynamics, which we discuss more thoroughly in the next subsection.
2.1.4 Is a High EIS in Combination with Long-Run Risks Plausible?

With recursive preferences, the EIS determines the consumer’s preference to smooth consumption over time, while RRA determines her preference to smooth consumption over states. Apart from that, the combination of both parameters pin down the consumer’s preference for early or late resolution of uncertainty: Epstein and Zin (1989) suggest two consumption schemes A and B which both exhibit two paths of future consumption (say, a good and a bad path). Consumption in periods 0 and 1 are identical for both paths in both schemes. The only difference between the schemes is that the consumer knows already in period 1 if she is on the good path in scheme A while she has to wait until period 2 to get that information in scheme B. Hence, scheme A (B) exhibits early (late) resolution of uncertainty. Epstein and Zin (1989) show that the consumer is indifferent between schemes A and B if and only if $\psi = \gamma^{-1}$, that is, in the time-additive version of the model. She prefers early resolution of uncertainty if $\psi > \gamma^{-1}$ and late resolution of uncertainty if $\psi < \gamma^{-1}$.

Epstein et al. (2014) work out this thought for more reasonable consumption schemes. In particular, they define a timing premium, which quantifies the fraction of lifetime utility the consumer is willing to surrender in order to resolve all uncertainty in a given consumption scheme. In particular, the consumer in this case would know the entire consumption stream, however, without being equipped with the ability to use that information to re-optimize. For the consumption dynamics in the original long-run risks model of Bansal and Yaron (2004) an EIS of 1.5 in combination with an RRA of 10 leads to a timing premium of 31%. Although the authors acknowledge that introspection about such a value might be difficult, they conclude that a timing premium of 30% and more (the consumption process in the rare disaster model of Wachter (2013) even yields a premium of 40%) seemed implausible.

Such concerns, however, do not necessarily preclude high values of the EIS. Epstein et al. (2014) point out that the timing premium also depends on the consumption dynamics. With i.i.d. consumption growth, an EIS of 1.5 and RRA of 10 lead to a much smaller timing premium of only 9.5%. Of course, i.i.d. consumption growth comes along with the well-known problems such as the equity premium puzzle. The challenge is thus to either find growth dynamics that fit asset pricing moments well even when the consumer’s EIS is small (Epstein et al. (2014) state that “we are not aware of such a process”), or to allow a higher EIS but specify growth dynamics that do not lead to implausible timing premia while solving asset pricing puzzles.

2.2 Time-Additive CRRA Preferences

We now discuss the time-additive CRRA model, which was considered the standard model of consumer preferences for a long time and is explored empirically by the majority of articles about intertemporal substitution in consumption. The model was originally put forward by Grossman and Shiller (1981), Grossman and Shiller (1982), Hall (1978), and Lucas (1978). From today’s perspective, the timing premium in the model is nullified at the cost of constraining the EIS to be the inverse of the RRA parameter. Our inability to specify an endowment process that solves asset pricing puzzles given time-additive CRRA preferences does not render the estimation of the parameters in this model unnecessary. It might, however, be difficult to interpret the estimated parameters, as is pointed out by Hall (1988).

2.2.1 Log-Linearization of the Euler Equation

Just as in Section 2.1.2, we may consider a log-linearized version of the Euler Equation. Introducing $\theta = 1$ into Equation (8) gives the regression equation

$$
\Delta c_{t+1} = -\psi \delta + \psi \mathbb{E}_t \left[ r_{t,t+1} \right] + \frac{1}{2} \psi \sigma_t^2 + \varepsilon_{t+1}
$$

(14)
which can be used for empirical tests and parameter estimates. It is usually assumed that consumption growth and returns are homoskedastic, that is, $\sigma^2_t$ is a constant.

Mankiw (1981) estimates $\psi$ in regression Equation (14) with an instrumental variable approach. Ordinary least squares regressions suffer from the problem of endogeneity, which makes the instrumental variable regression the preferable choice for the estimation of the log-linearized model. $\psi$ is positive but never significant in all of his regressions.

In contrast, Summers (1981) and Hansen and Singleton (1982) find coefficients significantly different from zero. Both studies rely on similar proxies but estimate Equation (6) with GMM. Summers (1981) finds an EIS around 0.4, while the estimate of Hansen and Singleton (1982) is about unity. Among other instruments, both studies include once lagged consumption growth as an instrument.

Hall (1988) carefully analyzes the consequences of aggregating consumption and return data over time. He argues that the use of once lagged consumption growth as instrumental variable would lead to endogeneity and that the high EIS estimates found by Summers (1981) and Hansen and Singleton (1982) would be due to this time-aggregation bias. This statement is corroborated by a counterfactual analysis in which he gains similar results as Hansen and Singleton (1982). If this endogeneity problem is circumvented by relying on other instruments, EIS estimates in his study are all insignificant. Hall (1988) thus concludes that “the elasticity is unlikely to be much above 0.1, and may well be zero.” This statement predominantly influences the discussion about the EIS until today. Hall (1988) is still the most-cited study about intertemporal substitution. However, in a later study, Hansen and Singleton (1996) account for the endogeneity problem as well and corroborate the findings of their earlier study.

The majority of studies discussed in Section 2.1 tried to find an answer to the question if the EIS is below or above 1. The early empirical literature about the EIS within the CRRA model discussed about if the EIS is different from zero. From today’s perspective, low EIS estimates seem to be a result of imposing time-additivity in the intertemporal utility function. A nearby reason for that phenomenon could be that imposing $\psi = \gamma - 1$ leads to estimation of a parameter that could be interpreted as the consumer’s inverse RRA instead of her EIS or a mixture of both. If $\psi > \gamma - 1$, this would lead to a downward bias in EIS estimates. Apart from that, we will discuss various variants of the time-additive utility model given by Equation (4), which consider other felicity functions that yield higher EIS estimates compared to the standard CRRA felicity function, in the following sections.

2.2.2 Rule-of-Thumb Consumers

The intertemporal decision theory outlined in the beginning of this section implies consumption smoothing over the consumer’s life-cycle. Campbell and Mankiw (1989, 1990, 1991) suggest that this may only hold for a certain group of consumers. For example, a myopic consumer would simply spend a period’s income for consumption in that period, instead of spending a fixed fraction of the long-term income (often called permanent income). Such a consumer is called rule-of-thumb or current income consumer. Apart from myopia, a reason for consuming current income could be liquidity constraints. An important assumption of the life-cycle model is that consumers are able to prepone consumption, that is, to borrow against future income. Hayashi (1985), Hayashi (1987), Hubbard and Judd (1986), Jappelli and Pagano (1994), and Mariger (1987) study the effect of liquidity constraints on consumption. Another interpretation of liquidity constraints is that consumers, even if not borrowing constrained, may build a buffer stock due to precautionary motives (see Deaton (1991) and Carroll (1992)). All these behaviors lead to suboptimal consumption plans in the view of a consumer with time-additive CRRA preferences.

Campbell and Mankiw (1989) assume that a fraction $\lambda$ of a period’s labor income goes to rule-of-thumb consumers, that is, is consumed instantly, while the rest goes to consumers who act in line with the time-additive CRRA model. For the former group this implies that consumption growth equals income.
growth. Campbell and Mankiw (1989) use the regression equation
\[ \Delta c_{t+1} = a + br_{t} + \lambda \Delta y_{t+1} + \epsilon_{t+1} \]
to estimate the parameter \( \lambda \) in the aggregate. Here, \( \Delta y_{t+1} \) denotes log income growth. From \( b = (1 - \lambda) \psi \) the EIS can be recovered and it becomes clear that estimates of the EIS from Equation (14) are (probably downward) biased if a considerable fraction of the population follows the “rule of thumb.” Campbell and Mankiw (1989) estimate \( \lambda \) to be around 0.5 and an EIS around 0.2 and insignificant.

In Campbell and Mankiw (1991), the authors point out that the fraction of rule-of-thumb consumers is lower in countries with well-developed credit markets, a finding that is supported by Jappelli and Pagano (1989). We come back to this issue in Section 4.1. Further studies that estimate the EIS in the presence of rule-of-thumb consumers are Hahm (1998), who estimates an EIS around 0.8, and Patterson and Pesaran (1992), who estimate an EIS around 0.3. The estimates in both studies are significantly different from zero.

Weber (2000, 2002) suggests that the detection of a nontrivial fraction of rule-of-thumb consumers might be an artefact of the time-additive CRRA model. He shows that relaxing time-separability through recursive preferences (Weber (2000)) or habit formation (Weber (2002), see Section 2.3) leads to a fraction of rule-of-thumb consumers close to zero.

Despite Weber’s conclusion that the concept of rule-of-thumb consumers might be obsolete once we allow for more general preference representations, it is important to keep in mind that neglecting the concept while working with time-additive CRRA preferences might lead to a severe downward bias in EIS estimates. However, a more reliable statement about the magnitude of the EIS in the time-additive model is difficult to make.

### 2.3 Subsistence and Habit Formation

The felicity function introduced in Equation (3) implies intertemporally homothetic preferences. Almost all papers discussed up to now stick to that assumption. In this section, we discuss studies that explicitly allow for nonhomothetic preferences and possible consequences for the EIS. Consider a felicity function
\[ u(C_t, X_t) = \frac{(C_t - X_t)^{1-\phi}}{1 - \frac{1}{\phi}}, \text{ if } \phi \neq 1 \text{ and } u(C_t, X_t) = \log(C_t - X_t) \text{ if } \phi = 1 \] (15)

where \( X_t \) constitutes a minimum consumption level. The consumer only gets utility from consumption if it is above this reference point. Different designs of the evolution of that reference point yield different interpretations of the respective model. We briefly discuss the most common specifications.

Eichenbaum and Hansen (1990) assume a constant value for \( X_t \), while Ferson and Harvey (1992) define it as a deterministic function of time that is \( X_t = x_1 \exp(x_2 \cdot t) \). In both cases \( X_t \) is called subsistence level or bliss point.

Sundaresan (1989), Constantinides (1990), and Ferson and Constantinides (1991) let \( X_t \) be a function of past consumption, which in addition to nonhomotheticity implies intertemporal nonseparability. For instance, Ferson and Constantinides (1991) define
\[ X_t = x_0 \sum_{s=1}^{\infty} x_s C_{t-s} \] (16)
such that \( x_s \geq 0 \) for all \( s \geq 1 \) and \( \sum_{s=1}^{\infty} x_s = 1 \). A widely used special case is \( x_1 = 1 \) and \( x_s = 0 \) for all \( s \geq 2 \), which implies that the consumer always claims a consumption level that is at least \( x_0 \) times the own consumption level of the previous period. Such a specification is thus called internal habit formation.
Abel (1990) and Campbell and Cochrane (1999) suggest a specification in which the consumer compares own consumption with aggregate consumption or consumption of members of a peer group. This external consumption measure can be contemporaneous or lagged. Such a specification is called **external habit formation** or *catching/keeping up with the Joneses*. Studies that work with aggregate data, however, usually do not distinguish between internal and external habit formation.

An argument similar to the one given at the beginning of Section 2 leads to the Euler equation

\[
1 = E_t \left[ e^{-\delta} \left( \frac{C_{t+1} - X_{t+1}}{C_t - X_t} \right)^{-\frac{1}{\varphi}} R_{t+1} \right] \tag{17}
\]

It is important to note that the curvature parameter \( \varphi \) is not equal to the consumer’s EIS. As shown in Atkeson and Ogaki (1996), Constantinides (1990), and Korniotis (2010) for different specifications of the reference point, the EIS is given by

\[
\psi_t = \varphi \left( 1 - \frac{X_t}{C_t} \right) \tag{18}
\]

The habit model drives a wedge between EIS and RRA, however, compared to the Epstein and Zin (1989) model, both quantities are still linked through the structural parameters of the model. The term that links the curvature parameter with the EIS is sometimes called **surplus consumption ratio**. In general, it is time-varying, which implies time-variation in the EIS as discussed in Section 4.4. Some of the studies reviewed in the following report “steady-state” values of the EIS.

The intuition behind Equation (18) is that a consumer whose consumption level is always close to the reference point is not willing to substitute consumption over time. This relates the rationale discussed in this section with rule-of-thumb consumers discussed in Section 2.2.2.

Atkeson and Ogaki (1996) impose separate but fixed subsistence levels for different goods in a multiple goods-framework. They report EIS estimates between 0.5 and 0.8. Based on their estimates of the subsistence levels they are able to show that the EIS is larger for wealthier households in India. This is an interesting pattern, which we will take up again in Section 3.2.

Ferson and Harvey (1992) assume a reference point that is deterministically growing and estimate a curvature parameter \( \varphi \) of 0.57 based on nondurable consumption, and 0.025 based on services consumption. To draw conclusions about the magnitude of the corresponding EIS values is difficult, since the average surplus consumption ratio is not reported. It is clear, though, that the estimate based on services consumption is very close to zero. They also investigate models in which the reference points are proportional to consumption in the preceding quarter, or the respective quarter in the preceding year. In the first case, the estimated curvature parameter based on nondurable consumption is 1.2 with an estimated habit parameter \( x_0 \) (see Equation (16)) of 0.37, which implies an EIS of about 0.76. The authors estimate the time-additive CRRA model as well and find a considerably lower EIS, around 0.05. Moreover, the model performance of the habit model, evaluated with the help of goodness-of-fit tests and Hansen and Jagannathan (1991) bounds, is substantially better compared to the time-additive CRRA model. This result is corroborated by Hyde and Sherif (2010), who moreover show that the habit model also outperforms a model that includes housing. The estimated curvature parameters \( \varphi \) are around 20, which implies an EIS of around 0.54 in the steady state given a long-run mean of the surplus consumption ratio of 0.027.

A similar approach is carried out by Stock and Wright (2000), who find negative values for the curvature parameter \( \varphi \) and habit parameters \( x_0 \) around 0.1, Leith and Malley (2005), who use a slightly different functional form and estimate a curvature parameter of 0.51, and Pagano (2004), who estimates the inverse of the curvature parameter, which is close to zero and estimated quite imprecisely. All these results do not allow a reliable statement about the magnitude of the EIS in this model.
Weber (2002) sets up a model in which he allows for habit persistence and a fraction of rule-of-thumb consumers. His results speak in favor of the time additive model in the nonhomothetic version presented in this section, as the estimated fraction of rule-of-thumb consumers is insignificant (in some estimations even negative) once he allows for internal habit persistence.

All studies discussed in this section use the original (nonlinear) Euler equation that emerges in the habit model as given in Equation (17) to estimate model parameters with GMM. Dynan (2000) uses a log-linearized form of Equation (17), which relies on the approximation \( \Delta \log(C_t - x_0C_{t-1}) \approx \Delta c_t - x_0\Delta c_{t-1} \), given by

\[
\Delta c_{t+1} = a + br_t + \lambda \Delta c_t + \varepsilon_{t+1} \tag{19}
\]

The parameter \( b \) corresponds to the EIS which is estimated at 0.54. This approach is followed by Smith and Yetman (2012) who use consumption and inflation forecasts from the Survey of Professional Forecasters. By using consumption growth forecasts for different quarters they are able to set up an “expected” version of Equation (19), that is, they work with forecasts rather than realizations of macro quantities. Similar to Pagano (2004) they estimate the inverse of the EIS close to zero (sometimes even negative) with large standard errors what makes the estimates difficult to interpret. It seems though, that the estimated EIS is larger if habit is included.

Korniotis (2010) also uses a log-linearized version of the Euler equation and includes internal and external habits in the utility function. From a panel of U.S. states, he includes own lagged consumption to account for internal habit formation and different weighted averages of lagged consumption of other states to account for external habit in the regression equation. For all investigated specifications of the external habit stock, the coefficients of the external habit proxy are significantly positive while those of the internal habit proxy (own lagged consumption) are insignificant. Whether these findings are related to individual decision patterns of consumers remains unclear, though. The estimated EIS is close to 0.6 for all tested specifications.

While some papers reviewed in this section suggest that allowing for habit formation may lead to higher EIS estimates, most papers rather provide estimates of the parameter as a side product. The focus of these studies is the fit of the habit model in general. Focussing on the EIS in combination with habit formation would probably lead to more exhaustive answers. It is interesting, however, that almost all studies find EIS estimates around 0.6, which is higher than most of the estimates in papers that consider the nested time-additive CRRA model.

2.4 Multiple Consumption Goods

Up to this point, all cited papers report EIS estimates based on single consumption goods or indexes, mostly nondurables and services. The consistency of these estimates requires the assumption that the respective consumption good is intratemporally separable from other consumption goods, which intuitively means that decisions about consumption of one good are independent from decisions about consumption of another. Let \( C_1, \ldots, C_N \) denote consumption of \( N \) different consumption goods.\(^9\) A widely used example of a separable felicity function \( u \) is the additively separable addilog function

\[
u(C_{1,t}, \ldots, C_{N,t}) = u_1(C_{1,t}) + \ldots + u_N(C_{N,t}) \tag{20}
\]

with separate utility functions \( u_1, \ldots, u_N \). In conjunction with time-additivity this implies that the intertemporal utility function \( U \) can be represented by a sum of intertemporal utility functions \( U_1, \ldots, U_N \) with intertemporal consumption plans of single goods as arguments as described in Section 2.2. Thus, the consumer evaluates consumption plans for each single good separately and the EIS of each good can be estimated independently from the other goods. If for example power utility functions are used, that
is, \( u_n : C_{n,t} \mapsto C_{n,t}^{1-\psi_n^{-1}}/(1-\psi_n^{-1}) \), then \( \psi_n \) denotes the EIS in consumption of good \( n \) for \( n = 1, \ldots, N \). Differences across the EIS parameters induce intratemporally nonhomothetic preferences.

Many studies suggest, however, that separability is a strong assumption that may bias estimates of the substitution elasticity. Eichenbaum and Hansen (1990) relax the assumption of separability by introducing the CES felicity function

\[
    u(C_{1,t}, \ldots, C_{N,t}) = \frac{1}{1 - \psi^{-1}} \left[ a_1 C_{1,t}^{1-\vartheta_t^{-1}} + \ldots + a_N C_{N,t}^{1-\vartheta_t^{-1}} \right] \prod_{n=1}^{N} \frac{1-\vartheta_t^{-1}}{1-\psi^{-1}} \tag{21}
\]

Here, \( \vartheta \) is the elasticity of intratemporal substitution between the consumption goods \( C_1, \ldots, C_N \) and \( \psi \) denotes the EIS in the composite good \( [a_1 C_{1,t}^{1-\vartheta_t^{-1}} + \ldots + a_N C_{N,t}^{1-\vartheta_t^{-1}}]^{1/(1-\vartheta_t)} \).

Another possibility is to use a Cobb-Douglas type felicity function, that is,

\[
    u(C_{1,t}, \ldots, C_{N,t}) = \frac{1}{1 - \frac{1}{\psi}} \left[ C_{1,t}^{\vartheta_1} \cdot \ldots \cdot C_{N,t}^{\vartheta_N} \right]^{1-\frac{1}{\psi}} \tag{22}
\]

such that \( \vartheta_1 + \ldots + \vartheta_N = 1 \). Both approaches imply homotheticity across different goods. Pakos (2004) generalizes the felicity function in Equation (21) and allows for intratemporal nonhomotheticity. This can be achieved by introducing distinct \( \vartheta \)'s for the different consumption goods. Crossley and Low (2011) and Okubo (2008b) argue that such a felicity function may cause the EIS to vary over time. If some consumption goods are easier to substitute intertemporally compared to others, the EIS of the whole consumption bundle varies with variation of the budget shares spent on different goods.

We now discuss papers that incorporate more than one consumption good and the consequences for EIS estimates. In particular we look at nontradable goods, durable goods, houses, luxury goods, leisure, and government spending.

### 2.4.1 Importables and Nontradables

With tradable we mean that the good can be exported to or imported from other countries. An early study that features this issue is Ostry and Reinhart (1992). They impose that the intraperiod utility function of the representative consumer in the home country is of the CES type. Exportable goods serve as the numeraire, which enables a simple interpretation of the relative prices of the other goods: The relative price of importable goods are given by the terms of trade, while the inverse of the relative price of nontradables is given by the real exchange rate. Ostry and Reinhart (1992) set up Euler equations that contain the terms of trade and exchange rates and estimate parameters based on data from 13 developing countries. The estimated EIS parameters are 0.45 in Africa and Latin America and 0.80 in Asia, both with small standard errors. The authors also estimate the EIS based on the same data set with the help of Equation (14) and find elasticities that are not significantly different from zero. They conclude that “a statistically significant intertemporal elasticity of substitution is not a product of the choice of countries or period covered in our sample. It rather suggests that, in estimating the parameters of consumer preferences, it is important to relax some of the assumptions underlying [Equation (14)]. Specifically, in our case, it indicates the importance of disaggregating between traded and nontraded goods.”

Ogaki et al. (1996) corroborate this finding. Based on the same method, they estimate parameters from a data set that covers 85 developing countries and find that the EIS varies and depends on the per capita income (see Sections 4.1 and 3.2). Their estimates are all significantly above 0 and significantly below 1 and range from 0.34 for the poorest countries to 0.63 for the richest.

Cashin and McDermott (2003) look at data from five industrial countries and estimate the EIS between 0.43 and 2.67. Just as Ostry and Reinhart (1992) and Ogaki et al. (1996) they use a CES felicity function. The same holds true for Chihi and Normandin (2012) who, however, interpret tradables as a bundle of home and foreign tradable goods whose utility is evaluated via a further CES function. Based on 12
developing countries, their EIS estimates for the full bundle of consumption goods range from 0.385 to 0.932, depending on the country.

Amano and Wirjanto (1996) use an addilog felicity function and distinguish between domestically produced and imported goods. They find that imported goods are more easily substituted with an EIS of 0.9 compared to 0.6 for “home goods.” Further studies that rely on addilog representations are Bekaert (1994) and Jimenez Martin and de Frutos (2009), who estimate an EIS between 0.26 and 0.56, depending on the instrument set, and between 0.41 and 1.33, depending on the country, respectively.

The results reviewed in this section show that neglecting nonseparability between different consumption goods, such as tradables and nontradables, may lead to EIS estimates that are downward biased. Findings in 2.4.2 will corroborate that estimation of the EIS based on single aggregated consumption measures may lead to counterfactual results.

2.4.2 Durables

Goods that are not perishable or invalidated shortly after their purchase, such as cars and furniture are called durable goods or durables. Usually, durables enter a utility function through the service flow that they provide to the consumer. It is assumed that this flow is proportional to the stock of durables, which is given by the depreciated stock of the last period plus recent purchases of durable goods. An early study that incorporates durable consumption is Hayashi (1982) who simply adds it to the consumption of nondurables and services. Bayoumi (1993) follows this approach and estimates an EIS of 0.3, significantly different from zero. Although he presumes that the use of nondurable consumption data would lead to insignificant estimates, he does not perform an additional estimation to confirm this statement. Mankiw (1985) fills this gap. He uses an addilog utility function and estimates an EIS of about 0.3 for nondurables and of about 0.5 for durables. Both estimates are rather imprecise, however.

Bernanke (1985) early noticed that the service flow of durable consumption may enter the utility of consumers in a nonseparable way. The first studies that feature nonseparability between durables and nondurables are Dunn and Singleton (1986), who consider a Cobb-Douglas felicity function and estimate an EIS between 0.52 and 0.82, and Eichenbaum and Hansen (1990), who consider a CES felicity function and restrict the EIS to estimate other parameters. The former approach is followed by Wirjanto (1991), who also uses a Cobb-Douglas function but does not provide estimates of the EIS.

The far more prominent approach, however, is to use a CES function or its non-homothetic generalization. Ogaki and Reinhart (1998b) find insignificant EIS estimates close to the values of Hall (1988) if separability is presumed. In the presence of nonseparability, however, their estimates are significantly positive (around 0.4). They argue that “ignoring the intratemporal substitution between nondurables and durables is likely to result in a misspecification bias that increases the probability of finding small positive [...] or even negative point estimates of the [EIS].” Further studies that use a CES utility function are DelaCruz et al. (2007) (who estimate an EIS between 1.5 and 3.2), Fauvel and Samson (1991) (EIS between 1.5 and 2.3), Gomes et al. (2009) (EIS = 0.66), Kim and Ryou (2012) (EIS = 2), Ogaki and Reinhart (1998a) (EIS = 0.75), Okubo (2011) (EIS between 0.96 and 3.9), and Yogo (2006) (EIS = 0.024). Except for the latter, all these papers report estimates that are significantly different from zero, most of them with confidence intervals that contain 1 or are even above 1. Yogo (2006) estimates a model with recursive preferences and approximates the return on the wealth portfolio by a stock market index, which may explain the low estimates (see Section 2.1.1).

Pakos (2011) generalizes the homotheticity imposed by the studies discussed so far by allowing for various θ’s in Equation (21). He finds evidence against homotheticity in aggregate consumption data. In his empirical exercise ignoring nonhomotheticity leads to “a striking bias in the estimates of the magnitude of the intertemporal and intratemporal substitutions.” Controlling for non-homotheticity leads to very low EIS estimates (about 0.04) compared to higher values if homotheticity is imposed. Okubo (2008a,b) uses
a similar approach and also finds lower estimates of the EIS if he allows for non-homotheticity. To make his results comparable with earlier studies he uses the same data as Ogaki and Reinhart (1998b) and finds that the EIS is still significantly positive under nonhomotheticity. His EIS estimates cluster around 0.25. Okubo (2008b) furthermore finds a higher $\theta$ for the durable good compared to the nondurable and interprets this as “the nondurable good is a necessity and the durable good is a luxury.”

The papers reviewed in this section question the common procedure that is approximating consumption with a single consumption good or index. On the one hand, ignoring non-separability between durables and nondurables leads to a downward bias in estimates of the EIS. On the other hand, although this result is less established than the former, ignoring nonhomotheticity between durables and nondurables may lead to an upward bias in EIS estimates. That these results only hold for durables and nontradables seems unlikely. The analysis of the impact of nonseparability and nonhomotheticity between further goods is an important task for future research.

### 2.4.3 Houses, Luxury Goods, Leisure, and Government Spending

One special good that is extremely durable is a house. Iacoviello (2004) sets up a two-agent model in which one agent is borrowing constrained while the other is not. The unconstrained agent evaluates nonhousing consumption and housing with respect to an additively separable utility function. The constraint of the other agent is linked to the value of housing and his utility function for consumption is logarithmic for simplicity. The author derives a regression equation which generalizes Equation (14) and estimates an EIS between 0.4 and 1, depending on the instrument set. Since the focus of the study is not the estimation of the EIS, it is not clear, however, if and in which way these estimates depend on the special assumptions implied by the model.

A more direct approach is chosen by Hyde and Sherif (2010) who consider housing and nonhousing consumption in a CES utility function. They estimate an EIS between 1 and 5.8. Flavin and Nakagawa (2008) impose nonseparability between consumption and housing as well. They furthermore consider adjustment cost for housing services. Based on their model, they show that adjustment costs may have an impact on the magnitude of the EIS. Their estimates, however, cluster around 0.13 for all investigated cases.

Based on the latter two papers, it is not clear whether housing is an important determinant for the estimation of the EIS. It would be interesting, though, to compare EIS estimates in the presence of housing with conventionally estimated values and to relate the findings to those reviewed in Section 2.4.2.

Ait-Sahalia et al. (2004) use an addilog felicity function to account for utility of basic consumption goods and luxury goods, such as jewelry and watches, boats and aircraft, sports cars, or luxury retail sales. They impose a positive subsistence level for the basic good and a negative subsistence level for the luxury good. This implies that marginal utility of the basic consumption good is much higher than that of the luxury good at low wealth levels, such that only wealthy consumers purchase luxuries. A negative subsistence level implies that the EIS is greater than the parameter $\varphi$ in Equation (15). The estimates provided in the study vary substantially, depending on the luxury good used for the estimation, such that a reliable statement about the magnitude of the EIS estimates is hard to make. The author nonetheless conclude that it “is possible that the EIS is larger for the consumption of luxuries” compared to basic consumption goods.

Kugler (1988) includes leisure in a two good utility function similar to that in Equation (20). He imposes that the elasticity coefficients of consumption of nondurables and services and leisure (calculated as the quarterly working hours subtracted from the quarterly time endowment of 1456 hours) are equal and estimates an EIS around 1 from aggregate U.S. data. A further study that includes leisure in a separable utility function is Leith and Malley (2005), who focus on monetary policy and find EIS estimates of 0.5.
Browning and Meghir (1991) strongly reject the hypothesis that preferences over consumption of
“commodities” are separable from leisure, that is, they reject the hypothesis $\theta = \psi$ in Equation (21). The
same statement is made by Kiley (2010) who studies the question of separability in a broader framework
including rule-of-thumb consumers (see Section 2.2.2) and external habit (see Section 2.3). Mankiw et al.
(1985) use a CES utility function as in Equation (21), and estimate an EIS of 5.7. They however reject
the model based on Hansen’s $J$-test.

Bean (1986), who works with U.S. data, and Hatzinikolaou (1999), who uses Greek data and allows
for rule-of-thumb consumers, use a Cobb-Douglas function as in Equation (22). They estimate values
around 0 and 1 for the EIS. Both studies do not only include leisure but also government spending. Bean
(1986) argues that “not all public spending is of the hole-in-the-ground variety; spending on services
such as health and education and on the police force is a substitute for private expenditure.” Although
this statement suggests that private and public consumption may not be separable, many studies include
government spending in an addilog utility function as introduced in Equation (20). Examples are Auteri
and Constantinou (2010), Ho (2004), and Nieh and Ho (2006) who estimate values of the EIS in private
consumption below 0.45, between 1.25 and 7.5 (depending on different subsamples, see Section 4.4), and
around 0.8.

Esteve and Sanchis-Llopis (2005) use a CES function and estimate an EIS of 0.74 based on Spanish
data. Pozzi (2003) and VanDalen (1995) use Cobb-Douglas functions. While the former finds negative
values of the inverse EIS and argues that this is due to a small sample bias, the latter estimates an EIS
around 0.5. Further studies that look at the impact of government spending are Amano and Wirjanto
(1997) and Balvers and Bergstrand (2002).

The results of the papers considered in this subsection are difficult to evaluate. Due to the fact that most
of them do not focus on the estimation of the EIS, it is difficult to draw conclusions about the possible
impact of allowing for nonseparability between houses, luxury goods, leisure, and/or government spending
on the one hand and nondurable consumption on the other. The studies that report parameter estimates
differ with respect to too many features, and, according to that, their result are very diverse, such that
even considering the papers jointly does not provide insights about that question.

3. Evidence from Microdata

All of the papers discussed so far use aggregate consumption expenditure data, that is macrodata. This
procedure is criticized by Slesnick (1998), since the data include spending of organizations that are likely
to not compare consumption plans as do private consumers. Furthermore, Runkle (1991) criticizes the use
of aggregate consumption data due to a possible aggregation bias in the cross-section. The assumption
of a representative consumer who optimizes life-time consumption based on aggregated data may be a
strong approximation of single households who make decisions based on individual data. Both suggest
the use of panel data instead. We discuss a number of studies that follow that approach in the following
section.

Panel data have some advantages compared to aggregate data: Apart from the large size of the data set
if single households are considered, demographic variables allow for conclusions about differences in the
cross-section of households. On the other hand, it is important to consider panels that feature households
that are representative for the population of interest. Browning and Lusardi (1996) give an overview of
representative surveys that provide information on household consumption and saving. The most widely
used are the U.S. American Consumer Expenditure Survey (CES henceforth, sometimes called CEX) and
Panel Study of Income Dynamics (PSID) and the British Family Expenditure Survey (FES).
3.1 Panel Data

An extensive discussion of the econometric methods that are suited to analyze the time-additive model with panel data is Runkle (1991). He points to a possible problem when working with panel data. The estimation of consistent parameters from regression Equation (14) with data of single households requires the error terms $\varepsilon$ to be independent both across households within each period and across time for each household. This would for instance be violated if differences in household behavior existed that could not be explained by variables that are available from the survey.

Lawrance (1991) uses the PSID and includes various demographic variables or *taste shifters* $Z_t$ in the Euler equation. More specifically, she assumes a felicity function of the form

$$u(C_t) = \frac{1}{1-\psi} \left( \frac{C_t}{\alpha(Z_t)} \right)^{1-\psi}, \text{ if } \psi \neq 1 \text{ and } u(C_t) = \log \left( \frac{C_t}{\alpha(Z_t)} \right), \text{ if } \psi = 1,$$

which (under the assumption $\alpha(Z) = \exp(\alpha_0 Z)$ for a parameter $\alpha_0$) leads to the regression equation

$$\Delta c_{t+1} = a + br_t + d \Delta Z_{t+1} + \varepsilon_{t+1}$$

For example, family size should have a direct impact on the utility of a certain amount consumed by a household and points to the importance of including taste shifters in micro studies that average out in the aggregate. Apart from family size, Lawrance (1991) includes age, race, and education. She finds an EIS around 1 for rich households and around 0 for poor households, which is in line with our findings in Section 2.2.2 about rule-of-thumb consumers, although she does not explicitly refer to that concept. Zeldes (1989) splits the households featured in the PSID into two groups (based on the wealth to income ratio), of which one is supposed to consist of liquidity constrained households. The time-additive CRRA model is rejected for the constrained households but not for the unconstrained, for which he estimates an EIS of 0.43. A similar approach with similar estimates is conducted by Runkle (1991), who however concludes that borrowing constraints are not a relevant issue in the United States.

Further studies that use the PSID are Dynan (1993), Engelhardt (1996), Keane and Runkle (1992), Runkle (1991), Shapiro (1984), Shea (1995), and Trostel and Taylor (2001). At large, the suggestion of Runkle (1991) that aggregation may lead to a downward bias in EIS estimates seems to be corroborated by these studies as most of them report EIS estimates that are significantly different from zero.

All papers reviewed so far in this section use food as measure of household consumption as it is the only consumption variable contained in the PSID. This approach is criticized by Attanasio and Weber (1995) who note that utility is likely to be nonseparable between food and other consumption goods (see Section 2.4). Runkle (1991) finds that 76% of the annual variation in food expenditures is noise. Furthermore, Browning and Lusardi (1996) note that it is ambiguous which period of time the food measures in the PSID refer to, since the survey asks “How much do you spend on food in an average week?”

The CES provides more thorough information on household spending on different consumption goods. It is, however, less informative about household characteristics and wealth. Parker (2000) uses the PSID and, by matching demographic and other variables featured by both surveys, *predicts* household consumption of nondurable goods and services, the same measure which is used by studies that rely on macrodata, as those discussed in Section 2.2.1. Further studies that rely on this procedure and use CES data are Attanasio and Weber (1995), Gourinchas and Parker (2002), and Gruber (2006). All papers estimate the EIS to be significantly positive, the latter two even report estimates above 1. This seems to further corroborate the relevance of an aggregation bias when aggregated data are used.

Studies that work with the FES, however, mostly find insignificant and low estimates of the EIS. Examples are Banks *et al.* (1994), Blundell *et al.* (1994), and Attanasio and Browning (1995). Although these findings are not directly comparable to those of the studies that use U.S. data, results of international studies (see Section 4.1) do not suggest that intertemporal substitution is much less pronounced in Britain.
Overall, the literature surveyed in this section must be interpreted as rather inconclusive about the magnitude of the EIS, just as the literature that relies on aggregated data. At the same time, the aggregation bias is well documented. Attanasio and Weber (1993) focus on this issue and show that relying on aggregated data biases EIS estimates downward. They look at cohorts of households in the FES and estimate an EIS of 0.8, with a confidence interval that contains unity, while their estimate is 0.4 and significantly lower with aggregated survey data. Beaudry and Wincoop (1996) use U.S. consumption data, split between different states and find an EIS around 1 and a considerable downward bias if the data is aggregated.

3.2 Limited Participation in Stock Markets

As just discussed in Section 3.1, Lawrance (1991) finds an EIS around 1 for rich households and around 0 for poor households. The arguments provided in Section 2.2.2 would explain this finding with the inability of the poor to substitute consumption intertemporally due to frequently binding borrowing constraints. However, even in the absence of borrowing constraints, the elasticity of wealthy households might be higher due to different compositions of consumption baskets. The arguments of Crossley and Low (2011) and Okubo (2008b), described at the beginning of Section 2.4, hence do not only explain variations in the EIS across time but also in the cross-section of consumers.

A further issue related to a household’s wealth is its participation in asset markets. Vissing-Jorgensen (2002b) argues that “high entry costs and per period market participation costs make it suboptimal with low or moderate financial wealth to enter these markets.” Blume et al. (1974), Blume and Friend (1978), Crockett and Friend (1963), and Mankiw and Zeldes (1991) study the demographics of stockholders. The latter find that “the fraction of households owning stock increases with average labor income, even holding education constant,” but also that “many wealthy households do not hold stocks.” Basak and Cuoco (1998) and Saito (1995) shed light on the reasons for limited stock market participation from a theoretical point of view. Guiso et al. (2008) argue that a lack of trust may explain limited participation and point to heterogeneity across countries.

Using data from the CES, Vissing-Jorgensen (2002a) estimates an EIS of 0.3–0.4 for stockholders and of 0.8–1 for bondholders, compared to estimates close to zero for nonasset holders. She argues that the representative investor, whose behavior could well be described by an intertemporal relation between consumption and asset returns such as the time-additive CRRA model, has to be distinguished from the representative consumer. Attanasio et al. (2002) show with FES data that the time-additive CRRA model cannot be rejected if consumption of stockholders is used. Their estimate of the EIS of stockholders is 2.5 based on return on shares and Treasury bills. Estimates from using the full sample of households are close to zero. Further studies that distinguish between stockholders and nonstockholders are Inkmann et al. (2011), who use data from the English Longitudinal Study of Ageing and focus on the annuity puzzle, and Vissing-Jorgensen and Attanasio (2003), who use data from the CES and estimate a recursive preference model (see Section 2.1). Estimates of stockholders’ elasticities in these studies are 0.4 and 1.4. The latter study furthermore finds an EIS of above 2 if only the top third in terms of stockholdings are included.

A comprehensive study relating stock market participation, substitution elasticities in different groups, and policy implications is Guvenen (2006). Based on theory and a simulation study, he emphasizes the importance of distinguishing between asset holders and non-asset holders. He concludes that “economic analyses as well as policy discussions based on average elasticities may be seriously misguided.” This critique is likely to apply to the majority of papers discussed in Section 2. This does not make the consideration of these papers worthless, it just means that we have to keep in mind that the EIS estimates from these studies may be severely downward biased.
4. Further Issues

In this section, we discuss further papers that estimate the parameters of the time-additive CRRA model, but give special attention to certain assumptions or data selection choices that are common in the empirical treatment of the model. In particular, we look at studies that (1) do international comparisons that cover several countries or look at other countries than United States or United Kingdom, (2) consider other asset returns than the return on a 3-month Treasury-bill or a broad stock market index, (3) allow for heteroskedasticity in consumption and/or returns, and (4) allow for a time-varying EIS.

4.1 International Evidence

As pointed out in Section 2.2.2, EIS estimates from different countries may be downward biased if there is a large fraction of rule-of-thumb consumers due to liquidity constraints in the respective countries. Campbell and Mankiw (1989, 1991) estimate models with rule-of-thumb consumers in developed countries in North America, Europe, and Japan, while Jappelli and Pagano (1989), Speight and White (1995), and Viard (1997) look at sets of developing countries and find larger fractions in these countries. Furthermore, there are studies about single countries such as Brazil (Cavalcanti (1993)), Greece (Hatzinikolaou (1999)), France (Girardin et al. (2000)), and Israel (Lavi (2003)). The first two studies report significantly positive EIS estimates, while the latter two report estimates close to zero.

Many other studies report EIS estimates from different non-United States and non-United Kingdom countries without including rule-of-thumb consumers. Koedlijk and Smant (1994) look at eight developed countries in North America, Europe, and Japan, while Nych and Ho (2006) study 23 OECD countries. Auteri and Constantini (2010) and DelaCruz et al. (2007) focus on the EU and Kim and Ryoo (2012) and Chyi and Huang (1997) on East Asia. Presumably due to the high data quality, many studies look at intertemporal consumption decisions in Japan, such as Hamori (1996), Noda and Sugiyama (2010), Okubo (2011), Osano and Inoue (1991), and Pagano (2004). Australia, New Zealand, and Canada are studied by Cashin and McDermott (2003), while Pozzi (2003) looks at Belgium, Tam and Lai (2009) at Hong Kong, Virk (2012) at Finland, Gleizer (1991) at Brazil, Bifman and Leiderman (1993) at Israel, Lybbert and McPeak (2012) at Kenya, and Atkeson and Ogaki (1996) at India. Finally, Bandiera et al. (2000) and Giovannini (1985) look at sets of developing countries.

As expected, the EIS estimates vary substantially across these studies. It is quite likely that the results do not only differ due to cultural differences between different countries, but also due to other issues such as econometric method, sample size, aggregation, etc. However, studies that consider large sets of countries and are consistent with respect to these issues point to the fact that the EIS might be a country-specific characteristic. It is well known that differences across countries impact economic decision making (see, e.g., Guiso et al. (2004, 2008), La Porta et al. (1998), Rieger et al. (2011), and Wang et al. (2011)). A thorough analysis of the EIS in different countries is given in a meta-analysis by Havranek et al. (2013), which includes several factors and report EIS estimates from 104 countries. They find large differences across countries, which indicates that the EIS is a country- or region-specific characteristic.

4.2 Alternative Return Proxies

The majority of papers discussed so far utilize returns on T-bills or stock indexes as proxies for $r$ in Equation (14). From a theoretical point of view, researchers may choose any asset since the Euler equation holds for all asset returns. Therefore, assets are selected which are likely to enable inference in small samples, that is, based on a statistical argument. The usual proxy is an (after tax) fixed income return for which the predictability by instrumental variables is higher compared to stock returns.
Mulligan (2002, 2004) questions the general validity of Euler Equation (6). He argues that the time-variation in expected returns of different financial assets cannot be explained by the covariance with consumption growth alone. He asks, “If the expected return on one financial asset rises, and the expected return on another falls, what should happen to consumption growth?” Instead of exploring further factors that may explain cross-sectional return variations, he aims to find an asset for which the consumption Euler Equation (6) is likely to hold.

The author constructs an after tax capital rental rate, that is, the ratio of capital income to capital, from time-series given in NIPA tables and estimates an EIS above one. His estimates based on the commercial paper rate and the return on the S&P500 are 0.14 and 0.09 with small standard errors and hence close to those of Hall (1988). His conclusion is that “consumption growth appears to be pretty elastic to the after-tax capital return (i.e. capital is elastically supplied), even while it appears inelastic to returns on various financial assets.”

A related approach is chosen by Dacy and Hasanov (2011) who aim to define a portfolio that represents the “market return.” They construct a “synthetic mutual fund encompassing all major classes of financial assets,” especially residential real estate. Using the return on this synthetic fund, they estimate an EIS of 0.15 with a small standard error, which is considerably lower than their estimate of 0.28 if a Treasury bill return is used. Since the choice of their proxy is motivated rather heuristically, it is however not clear whether Mulligan’s argument that Euler Equation (6) holds for the chosen asset applies here as well.

When working with panel studies it would be appealing to assign each household a specific rate of return that corresponds to the portfolio held by the respective household. This would lead to cross-sectional variation in the independent variable which helps to identify the EIS. Although in theory, each household is able to hold any traded portfolio, there might be reasons why certain households stick to certain assets. Some studies that use panel data (see Section 3.1) use household-specific tax rates as a first step. Engelhardt and Kumar (2009) go one step further and use households’ individual 401(k) savings from the Health and Retirement Survey (HRS). They estimate an EIS of 0.74 with a confidence interval of 0.37–1.21.

In summary, we may conclude that the choice of the test asset is irrelevant as long as we assume that the Euler Equation (6) describes asset prices reasonably well. If this is not the case for specific assets, EIS estimates might be biased if these assets are used for estimation. The papers presented in this section indicate that this concern might apply to some of the papers considered in the previous sections.

4.3 Including Variances

In the studies considered so far, the variance term \( \sigma^2_t \) in Equation (14) was considered constant over time and could hence be treated as a part of the intercept. However, the variance term represents one of the most important reasons for consumers to save, that is, postpone consumption, that is the precautionary savings motive. If economic uncertainty is time-varying, that is, consumption or interest rates are heteroskedastic, this may have a perceptible impact on EIS estimates, because an important variable that influences consumption growth is omitted. Heteroskedasticity of consumption growth is a standard assumption in many asset pricing models since Bansal and Yaron (2004) at the latest. Jones et al. (1999) investigate the relation between growth and economic uncertainty in a theoretical framework, while Kormendi and Meguire (1985) and Ramey and Ramey (1995) study this relation empirically with mixed results.

Carroll (2001) criticizes the log-linearization approach and the assumption of constant higher moments in general and argues that the higher moments in the Euler equation may be correlated with the interest rate in the presence of buffer stock savers. He states that “the omission of the consumption variance term can bias estimates of the EIS; a higher interest rate will lead to higher wealth holdings, which reduces the variance of consumption, lowering the growth rate of consumption. This offsets the EIS effect (a higher interest rate leads to a faster growth rate of consumption), so that the estimated EIS is biased downward.”
He, as well as Guvenen (2006), conduct simulation studies to emphasize the importance of including variances. Guvenen (2006) finds that an EIS of 1 can be precisely estimated if the non-constant variance term is included in the regression Equation (14). Omitting the variance term in the regression leads to an EIS estimate of only 0.5.

Although this “homoskedasticity bias” is studied in detail in the theoretical literature, empirical studies that include variance terms are sparse. Studies that include volatility proxies in regression equations are Koskela and Viren (1987), who use volatility of inflation to account for heteroskedasticity in returns, Mehra and Martin (2003) who include an interaction term between real interest rate and its volatility, and Banks et al. (2001) who include income risk. EIS estimates of these three studies are negative for the first, around 0.2 for the second, and around 0.5 for the third. However, they do not focus on the impact of the homoskedasticity assumption on EIS estimates. In view of the extensive literature about volatility, it is necessary that this topic is studied in more detail from an empirical point of view.

4.4 Time-Varying EIS

Aggregate consumption data are available on a quarterly basis. The same is true for most survey data. It is difficult to detect time-variation in preference parameters such as the EIS if they have to be estimated based on such sparse data. Some authors nonetheless suggest that the EIS may vary over time. As discussed in Section 2.4, Crossley and Low (2011) and Okubo (2008b) argue that some consumption goods are easier to substitute intertemporally compared to others (see also the discussion about durable goods in Section 2.4.2 and on luxury goods in Section 2.4.3). The EIS of the whole consumption bundle varies with variation of the budget shares spent on different goods if preferences are intratemporally nonhomothetic.

Based on aggregate consumption data, Ferson and Merrick (1987) find that the time-additive CRRA model holds at least in nonrecession periods if one accounts for changes in monetary policy in 1951 and 1979 and for different stages of the business cycle (recession vs. nonrecession). In these periods, the link between consumption and interest rate shifts is much more pronounced. They estimate an EIS of 0.46 based on quarterly data and an EIS of 3.2 based on monthly data. Koedlijk and Smant (1994) support this finding with a study that covers eight developed countries. For each country, they estimate the EIS in unconditional Euler equation regressions as introduced in Equation (14) and find parameters close to and even below zero. Adding business cycles and regimes, however, leads to EIS estimates around 0.5 with small confidence intervals.

Several authors suggest that estimates of the EIS depend heavily on the sample that is used for estimation. VanDalen (1995) estimates an EIS of 0.14 based on data from 1833 to 1990 and of 0.55 based on data from 1948 to 1990. He furthermore splits the sample in peace and wartime and finds a considerably lower EIS during wartime. Esteve and Sanchis-Llopis (2005) suggest an increase in the elasticity in Spain during the postwar era. They find a regime shift around 1974 before which they estimate an EIS of 0.38, while afterwards the estimate is 3.84. Based on the full sample they estimate an EIS of 0.74. As long as we are interested in the current magnitude of the parameter, their results show a potential for severe downward biases in estimates caused by early subsamples.

Blundell et al. (1994) specify a framework in which a household’s EIS is a function of its consumption expenditure and compare the model fit and the parameter estimate with that of the iso-elastic alternative introduced in Section 2.2. They conclude that “allowing the intertemporal elasticity of substitution to vary with consumption, as opposed to using an iso-elastic specification, is important for the estimates. This extra degree of flexibility leads to higher estimates of the [EIS]. Moreover, we find that the [EIS] is very well determined.” For different groups within the sample they estimate mean values of the EIS between 0.58 and 0.89. Attanasio and Browning (1995) follow their approach and corroborate the finding that the EIS increases in consumption. Their estimates, however, are close to zero.
The results in this section indicate that it might be problematic to consider an unconditional version of Equation (14) and to nonreflectively replace the time-varying conditional expected consumption growth by realized consumption growth. It becomes apparent once more that the limitations of the one short consumption time series that we have make it difficult to meet all the requirements given by a full-fledged theory.

5. Conclusion

This paper reviews the status quo of the literature about the EIS in consumption. It sheds light on several aspects and model features that may impact the estimation of the parameter. After all, which answers can we give to the questions posed in the introduction?

(A) What is the true value of the EIS?

Hard to say. In almost every subsection of this paper we list studies that report estimates not significantly different from 0, as well as studies that report estimates above 1. The fact that one hardly finds studies that rely on comparable conditions in terms of estimation technique, sample size, used data, etc. renders a concise answer to that question impossible. We can, however, make a couple of qualitative statements. The discussion seems to have moved away from zero or positive? in the 1980s to below or above one? today. A large number of studies documents that the simplifying assumptions of the time-additive CRRA model may lead to downward biased estimates of the parameter. Most importantly, utility may be intertemporally nonseparable and risk attitudes should be disentangled from the willingness to substitute consumption over time. With recursive preferences, EIS estimates seem to be considerably higher than with time-additive preferences. One should then keep in mind that the combination of high EIS and high RRA may lead to implausible timing premia for certain specifications of the consumption dynamics. The idea that the plausibility of an EIS is inextricably linked with the consumption specification is the second major insight from our study. The use of aggregate consumption of nondurables and services may be inappropriate. On the one hand, including further consumption goods, such as durables, lead to high EIS estimates as they may be more easily substituted across periods. On the other hand, studies that use panel data document an aggregation bias and report higher EIS estimates when data of individual households are used. Especially the differentiation of the groups of consumers and asset holders seems to matter a lot.

(B) Can question (A) ever be answered properly?

Even if a well-specified decision model and a large and comprehensive data set were available, many aspects point to the impossibility of fixing one EIS. Just as with respect to risk attitudes, each consumer has a specific attitude toward intertemporal substitution. Many studies show that these attitudes vary substantially across individuals and are linked to demographic factors, especially wealth, education, and stock market participation. Even the determination of an average EIS seems difficult. It does not only seem to be country specific but also time-varying. We conclude that the EIS simply does not exist. This does not mean, however, that further empirical research in this field is a waste of effort. Especially due to the recent literature we have a much better understanding of the factors that influence elasticities in different frameworks. Just as proposed in many sections of this paper, more research is necessary to corroborate and broaden this picture. Especially, analyzing the impact of introducing further goods in multiple goods-settings or habit formation on the magnitude of EIS estimates seem promising. Moreover, it is necessary to better understand the properties of the aggregate wealth portfolio to allow unequivocal parameter estimates in models with recursive preferences.

(C) What is a reasonable choice of the EIS in representative agent models?
That depends on the model. If the model is ought to explain stock returns and their joint behavior with consumption innovations, one should try to represent preferences of the average stock market participant which is likely to have a higher EIS than the average consumer. The common choice of 1.5 seems pretty reasonable after all. However, for models that assume that the representative agent consumes a single nondurable consumption good, it seems difficult to argue against values that are considerably lower and clearly below one. Regarding the fact that stock market participation is positively linked to wealth and wealthy subjects spend large fractions of their permanent income on durables, one rather has to put into question the common practice to calibrate consumption-based asset pricing models with the one time-series of aggregated consumption of nondurables and services from NIPA tables. These data are filtered, smoothed, and adjusted and are not designed for meeting the requirements of asset pricing studies. This has been criticized by various authors such as Miron (1986) who points out that smoothing the data may “introduce measurement errors that will tend to produce rejections of the model even when it accurately describes the data.” More recently, Savov (2011) and Kroenke (1978) have proposed alternative consumption time-series. Hence, the discussion about how to specify the EIS should be accompanied with a discussion about a consumption time series that is suited to be used in empirical and theoretical asset pricing studies.

Notes

1. This equation relies on the assumption that the consumer’s preferences are time-additive with constant relative risk aversion (CRRA). See Section 2 and equations (6) and (14) for details.
2. Several generalizations of the uncertainty aggregator $u^{-1}(\mathbb{E}_t[u(U(C^{t+1}))])$, featuring “exotic” preferences, have been proposed and discussed discussed in the literature. Examples are multiple-priors preferences (see Gilboa and Schmeidler (1989), Epstein and Schneider (2003), and Hayashi (2005)), smooth ambiguity preferences (see Klibanoff et al. (2005, 2009) and Hayashi and Miao (2011), (generalized) disappointment aversion (see Gul (1991), Routledge and Zin (2010), and Bonomo et al. (2011)), or robust control (see Andersen et al. (2000), Hansen and Sargent (2001), and Skiadas (2003)). Empirical literature on the EIS in these models is sparse and we do not discuss them in this paper.
3. Exceptions will be spotlighted. We discuss multiple consumption goods in Section 2.4, nonaggregated data from surveys in Section 3.1, and alternative asset returns in Section 4.2.
4. Epstein and Zin (1989) interpret $\gamma > \psi^{-1}$ as a decision maker’s preference for early resolution of uncertainty, while $\gamma < \psi^{-1}$ corresponds to a preference for late resolution of uncertainty. We discuss this issue and related implications for the EIS more thoroughly in Section 2.1.4.
5. The only assumption we have to make is the “no bubbles condition,” that is the stationarity of the consumption-to-wealth ratio.
6. Note that the papers discussed at the beginning of this Section use (10) to substitute the return on wealth instead.
7. In case of internal habit formation, this equation only holds if $x_1 = 1$ and $x_s = 0$ for all $s \geq 2$, which is the special case that we discussed. A derivation of the general Euler equation can be found in Ferson and Constantinides (1991).
8. The authors refer to Wachter (2006) who estimates this value.
9. Usually, one of the consumption goods, for example, consumption of nondurables and services, serves as the numeraire, and all other quantities are expressed in terms of this good.
10. Chamberlain (1984) reviews the literature about the econometrics of panel data in general.
11. The authors use an indirect utility function. For details, see Deaton and Muellbauer (1980).
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