Subjective data in a test of the life cycle model

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Abstract

The life cycle model is a cornerstone model in modern micro– and macro economics. The life cycle model offers a rationale for savings behavior, as individuals or households are assumed to value future utility in current period decisionmaking. A frequently employed test on the validity of the life cycle model is based on the orthogonality conditions implied by the first order condition of the problem: the Euler equation of consumption (Hall 1978). Such tests are convenient as they do not rely on a specification of income processes for example. Conventional approaches subsequently define preferences (i.e., the marginal rate of substitution between future and current consumption) and test the empirical validity of this –one specific– parameterization of the model. In this paper I propose "self-reported changes in food consumption adequacy" as a direct proxy for the marginal rate of substitution of food consumption in two consecutive periods. Indonesian households were asked to rate the change in the adequacy of food consumption from a year ago until now on a five-point scale. The methodology has two clear advantages over conventional approaches. First, the test does not rely on ex ante specified preferences, such that it scrutinizes the validity of a life cycle model of unknown form (e.g., habit formation, within period nonseparabilities, etc. are implicitly allowed for).[1] Secondly, conventional tests may suffer from low power as it can be difficult to statistically distinguish an "extended life cycle model" from alternative theories of behavior. In this paper, I strongly reject the life cycle model with constant discount rates. The model with household specific discount rates is (only) borderline rejected.

Keywords: Stated preferences, Life cycle model, Euler equation, nonseparabilities.

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[1] I assume that the household is the unit of decisionmaking, and life time utility can be written as an exponentially discounted sum of current and future "within period" utilities. Also, standard regularity conditions apply, such that within period utility/felicity is concave.

1 Introduction

In this research I present new empirical tests of the life cycle model. I test the predictions of the Euler equation of consumption without relying on arbitrary functional form assumptions on preferences. I use data on "recollected changes in consumption adequacy" as a directly observed proxy of the marginal rate of substitution between current and last year's consumption [see section 2.1].[2] I strongly reject the life cycle model with constant discount rates, and I (borderline) reject the life cycle model with household specific discount rates.

The approach I propose has two clear advantages over conventional approaches: first, the empirical validity of *a* life cycle model of unknown form is tested. This limits the set of possible alternatives associated with a rejection, and paves the way for estimating preference parameters once the model cannot be rejected. Second, whereas conventional approaches typically have difficulties to empirically disentangle "extensions" to the baseline life cycle model[3] and alternative theories of behavior, my approach should be immune to this. For example, there are many competing explanations for the –often observed– simultaneous increase in both consumption and income in the early phases of the life cycle.[4] A directly observed proxy for the marginal rate of substitution that I propose in this research can be helpful to discriminate between different explanations.

Ever since its introduction in the 1950's, the life cycle model is the dominant framework to think about savings behavior (Modigliani & Brumberg 1954). In its most general appearance, households value future (expected) utility when making current period decisions. The forward looking nature of the life cycle model provides the main rationale for savings behavior. In anticipation of an income decrease, consumers respond optimally by rationing today's consumption and increase savings (Campbell 1987). Understanding savings behavior is important as (household) savings provide capital for economic growth. On the individual level, savings are an important means to insure consumption against adverse shocks in e.g.,

[2]The data is drawn from the household consumption panel, which is part of a much larger data collection effort: the Indonesian National Socioeconomic Survey (SUSENAS) [see section 2 for more].

[3]An "extended life cycle model" allows for e.g., preference shifts due to changes in demographics and labor supply.

[4]e.g., liquidity constraints, nonseparability with demographics, habit formation, ad hoc (Keynesian) consumption.

income.[5]

However, the life cycle model in and its applicability to real world decision-making has been criticized extensively in the literature (e.g., Carroll & Summers (1989) and Fernández-Villaverde & Krueger (2007), or see Browning & Lusardi (1996) for an overview "excess sensitivity" tests that are based on Euler equations). Different predictions of the life cycle model have been used to test the validity of the model. Carroll & Summers (1989) for example, study the cross sectional age-consumption profiles of fast and of slow growing economies. The life cycle model predicts that "at a point in time the age-consumption cross-section profile should be less positively sloped in a rapidly growing country than in a slowly growing country. This is because in more rapidly growing countries the old are much lifetime-poorer than the young so consumption of the old will be much lower relative to consumption of the young (Carroll & Summers 1989)". They do not however find evidence for this prediction, as these profiles are similar across different countries.[6]

Often however, criticism on the life cycle model originates from statistical rejections of yet another prediction of the model. Hall (1978) showed that under some assumptions[7] "no variable apart from current consumption should be of any value in predicting future consumption". Many scholars have been challenging this prediction [see e.g., Browning & Lusardi (1996) for a summary of papers that have done this.]

Despite heavy criticism and frequent statistical rejections, the life cycle model still features a central role in economics. One may wonder why a model would survive all this critique? First, its basic principles have great intuitive appeal. It seems logical that individuals today, care about their future wellbeing in some way. Moreover, Deaton (2005) argues that "without it, we would have much less to say about many important issues, such as the private and public provision of social security, the effects of the stock market on the economy, the effects of demographic change on national saving, the role of saving in economic growth, and the determinants of national wealth".

[5] The precautionary motive is implicit in some versions of the the life cycle model (Deaton 1990).

[6] Also, Fernández-Villaverde & Krueger (2007) and Alessie & De Ree (2009) show that consumption apparently tracks the hump shape in income over the life cycle. This is an apparent inconsistency with the theory as the hump in income can, at least in part, be anticipated.

[7] perfect capital markets, quadratic additive utility (certainty equivalence), rational expectations, and and exponential discounting where the interest rate equals the time discount factor.

A further reason for holding on to the life cycle model as the basic framework to think about savings behavior, is that empirical tests of the life cycle model often rely on strong *auxiliary* assumptions. Such assumptions are typically arbitrary (i.e., not implied by theory), such that a statistical rejection of the model should be interpreted as a simultaneous rejection of the basic principles of the model *and/or* of one or more of these auxiliary assumptions. That is, a rejection may be consistent with many alternative hypotheses, of which only one class is inconsistent with the life cycle model as a general representation of preferences: people do not smooth expected marginal utilities, but in fact do something else. Browning & Lusardi (1996) explain the survival of the life cycle model against many statistical rejections as follows: "the standard additive model has a number of *life belts* that may save it from drowning."

There are numerous examples of studies that argue that statistical rejections of the orthogonality conditions implied by the Euler equation are in fact due to errors in operationalizing the tests. Blundell, Browning & Meghir (1994) for example, find that excess sensitivity of consumption to anticipated changes in income can be explained by nonseparabilities with demographic variables (e.g., children). Carroll (2001) on the other hand, argues that log linearized Euler equations are inappropriate vehicles to estimate parameters (e.g., intertemporal substitution elasticities), particularly in a cross section of households. Also, Zeldes (1989) interprets excess sensitivity to income for low wealth households as evidence for the importance of binding liquidity constraints.

The fact that the model has great appeal *and* its ability to explain some real world phenomena, I argue, has motivated scholars to interpret a statistical rejection of the life cycle model as a failure of functional form (e.g., curvature of the utility function, non-separabilities within period or over time), institutional conditions (e.g., liquidity constraints), or estimation issues (small T dimension of survey data, or a failure of rational expectations). Indeed, not as a rejection of the fundamentals of the model. Within the tradition of testing the validity of the Euler equation of consumption, I relax some of these auxiliary assumptions (or life belts). In this research I use a directly observed proxy for the marginal rate of food consumption in two consecutive periods, and test the predictions of a general class of Euler equations of food consumption. The approach greatly narrows down the set of alternative hypotheses associated with a rejection of the model. As a result I propose a test on the validity of life cycle theory, rather than on the validity of *one specific* parametric representation of a life cycle model.

Conventional approaches typically employ log changes in consumption expenditures as a proxy for the marginal rate of substitution between this year's and next year's consumption. It is well known however, that such a linearization may be problematic as it eliminates the mechanism for precautionary savings [see e.g., Deaton (1991)]. Deaton (1991) considers that impatient households who cannot borrow typically engage in buffer-stock saving behavior. For these households, consumption growth is a crude, and for some purposes, inadequate proxy for the marginal rate of substitution of consumption in two consecutive periods.

The proxy that I propose is arguably much better. In this research I use recollected changes in consumption adequacy as a direct proxy of the marginal rate of substitution of consumption in two consecutive periods. A test on the basis of this proxy does not rely on functional form assumptions on preferences. That is, no assumptions need to be made on the curvature of the within period felicity functions, nor on within period separabilities. Also, the test is consistent under the usual types of intertemporal nonseparabilities (e.g., habit formation or durability). Finally, the approach is largely immune to measurement error that is known to plague consumption expenditure data obtained by household surveys (especially those where households do not use diaries, but are asked to remember what they have been consuming in the past). Especially, but not exclusively, in developing countries the problem of measurement error must be emphasized.

Although this approach solves a lot of problems, it also introduces new ones. Where data on direct measurements of preferences with subjective data is rapidly finding its way into mainstream economics, it is still largely unclear what many subjective measures actually mean, and, consequently, how they can be used. A priori, it is not obvious why recollected changes in (food) consumption adequacy is a good proxy for the marginal rate of substitution between current and lagged food consumption. Therefore, I will try to extensively justify my empirical strategy in section (2). Using subjective (or stated) preferences data as direct proxies of important economics concepts (other than a level of utility) is relatively new, and I would argue, has great potential. I test the validity of the life cycle model with constant- and with household specific discount rates. I find a statistical rejection of both models. However, one could argue that the rejection of the model that allows for individual specific discount rates is not "extreme" (even if there is perhaps no obvious criterion by which one could value the severity of a rejection).

Finally, I test the validity of the life cycle model in the context of a developing country (i.e., Indonesia). An extensive body of literature in development economics focusses on risk sharing within communities [e.g., Townsend (1994)]. However, households can only "insure" idiosyncratic risk by sharing the burden within the community, so, even if households are perfectly able to diversify their idiosyncratic risk, it only contributes to eliminating the idiosyncratic risk in the total. In reality, the supposition of perfect risk sharing seems too strict. This study is complementary to this literature as the uninsurable risk that the household is facing, should be dealt with in the same way as were risk sharing not possible.

2 Data description and the interpretation of *recollected changes in consumption adequacy*

For this research I use a new and unexploited household consumption panel data set drawn from Indonesian National Socioeconomic Survey (henceforth, SUSENAS). The original SUSENAS is a nationally representative survey among Indonesian households and interviews about 200,000 households on a yearly basis. Listings of consumption expenditure items of this broad survey however are rather limited. From 2002 up to 2004 the SUSENAS has sampled a subset (about 10,000 households) of the original SUSENAS to take part in a consumption panel.[8] In addition to a very detailed set of consumption expenditures and demographic variables, households were asked to rate their respective food and non-food consumption as adequate or inadequate to satisfy their particular households needs (only the 2003 and 2004 wave). This data has been used by De Ree, Alessie & Pradhan (2010) to estimate the price and reference utility dependence of equivalence scales. The exact phrasing of the questions is as follows:

[8] The attrition rate of this panel data set is about 10% per year.

Q1. In the past month, has your food consumption been adequate for your household needs?[9] [10]

1. no
2. yes
3. more than adequate
4. do not know

This type of self-rated consumption adequacy data has already been part in various surveys across (mostly) developing countries [e.g. Pradhan & Ravallion (2000) for Jamaica and Nepal and De Ree, Alessie & Pradhan (2010) for Indonesia].

For a large part, this research relies on a question that has been asked as a follow-up to the question above. After households were asked to value the adequacy of consumption (a question on *levels*), households were subsequently asked a question about *change*:

Q2. How did the level of food consumption adequacy change, compared to last year?[11] [12]

1. deteriorated a lot
2. deteriorated a little
3. no change
4. improved a little
5. improved a lot

[9] The SUSENAS has the same question for nonfood. I do not consider this data for this research.

[10] In Bahasa Indonesian: Bagaimana tingkat pemenuhan kebutuhan konsumsi makanan rumah tangga selama sebulan yang lalu?

[11] The SUSENAS has the same question for nonfood.

[12] In Bahasa Indonesian: Bagaimana keadaannya jika dibandingkan dengan tahun lalu?

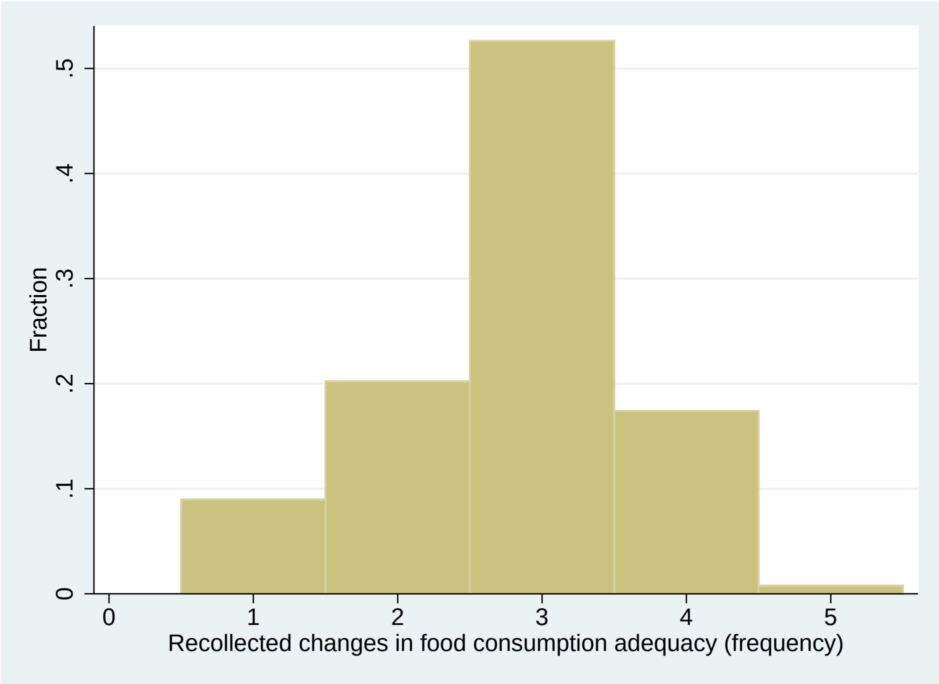

Figure 1: Frequencies of households reporting different answers to the changes in food adequacy recollection question: from 1 (deteriorated a lot) to 5 (improved a lot).

I will refer to this data as self-reported, or subjective recollections of changes in food consumption adequacy. Or in short, the recollections data $R = 1, 2, 3, 4, 5$. Figure (1) shows the frequencies of R in the data set (2003 and 2004 combined).

In what follows I will argue that the recollected changes in consumption adequacy is an appropriate proxy of the marginal rate of substitution of food consumption in two consecutive periods. I will consider degrees in *adequacy* of consumption and degrees in *satisfaction* with consumption to be the same thing. To my knowledge, direct measurement of this economic concept with stated or subjective preference data is a novelty. The empirical significance of this research depends however, to a large extent, on a correct interpretation of this data and it is consequently important to develop the intuition.

2.1 Interpreting recollected changes in consumption adequacy

The negative tension of *wanting* or *needing* a good or service can be resolved by satisfying the particular want or need (by e.g., acquiring the good or the service). Generally, satisfying a want generates a feeling of satisfaction with respect to that particular want. Satisfaction with x, therefore, is often associated with relaxing tensions of wanting x. I am proposing therefore, in general, that the degree of *dis*satisfaction with x is proxying the negative *tensions of wanting* x. I have borrowed this interpretation of satisfaction from the psychological or psychoanalytical literature. Sullivan (1953) elaborates on the issue as follows:".. the relaxation of the tensions called out by lacks of this kind [lack of water, lack of oxygen, lack of sugar] I call *satisfaction* of the specific need which was concerned (p. 37)." Questioning individuals about satisfaction therefore, is questioning individuals about the degree to which tensions of wanting are relaxed. Furthermore, and this is perhaps of additional importance to economists, Sullivan (1953) is directly linking tensions of wanting, to behavior:".. a need, while it is in a broad biological sense disequilibrium, acquires its meaning from the actions or energy transformations which result in its satisfaction (p. 37-38)."

In economics, such tensions –that cause a feeling of dissatisfaction *and* spur action to alleviate them– are characterized by *marginal utilities.* To see why, I go back to early 19th century economics, the era in which utility theory experienced some of its major breakthroughs. Early Austrian scholars, of which Gossen (1854, translated in English in 1983) was arguably the first, interpreted *marginal* utilities as a measure of the intensity or importance of the last want that is satisfied. On the basis of this logic, Austrians developed a theory about the shape of the utility function by supposing that the most important wants (with high marginal utility) are satisfied first. Wants of lesser importance were satisfied later. They conclude from this logic that marginal utility is decreasing, and hence, utility is concave. This logic has been the basis for the concavity of utility functions typically specified today. The utility functions that are usually introduced in demand analysis are typically quasiconcave. However, the rationale for quasiconcavity stems from the same logic.

The above provides a link between *satisfaction* of wants or needs and *marginal utility.* As far as I am aware, this is a novel interpretation of satisfaction data that opposes (or perhaps refines) the widely adopted unification of (income) satisfaction and "utility".

Sullivan (1953) considers the possibility of a state of full "equilibrium" by satisfying all tensions ["lack of oxygen, lack of sugar, lack of water,..."]. In realistic economic situations however, individuals never seem to be able to relax all tensions, and consequently live in a permanent state of "disequilibrium" (in the sense that tensions of needs cannot be fully satisfied). Due to money, price, or other constraints, individuals balance out the different needs and wants they have given the constraints they face.

With regard to the life cycle model, the above logic suggests that a situation where the degree of satisfaction with real consumption in two periods corresponds one-to-one to a situation where marginal utilities of real consumption are equal in two subsequent periods. This prediction, moreover, resonates very well with casual remarks of e.g., Deaton (2005), who also seems to suggest that *need satisfaction* and *marginal utilities* are the same thing: "people...tailor their consumption patterns to their needs at different ages."

It is however not to say that equalizing marginal utilities is primary objective of the consumer. Due to constraints on income, commodity prices, interest rates and time discount rates, the utility maximizing solution may not be that marginal utilities are equal over time, and consequently, nor do satisfactions with consumption.[13] Households may rationally accept a decrease in consumption satisfaction (i.e., an increase in marginal utilities) if one heavily discounts the future or if future commodity prices are high.

To further understand the working of this logic and its implications for testing the life cycle model I work out an example. I define a simple two-period life cycle model, where a household is supposed to maximize an additively separable utility function subject to a life time budget constraint. The within period felicity functions are allowed to depend on demographics z_t. I assume that borrowing or lending constraints are absent. The model can be written as follows:

$$\max_{\mathrm{c}_1,\mathrm{c}_2} E_1\left[u\left(\mathrm{c}_1,\mathrm{z}_1\right)+\beta u\left(\mathrm{c}_2,\mathrm{z}_2\right)\right] \tag{1}$$

where E_1 is the expectations operator conditional on information known to the decisionmaker

[13]Note that the life cycle model is a special case of a more general utility maximizing model. The life cycle model is unique in the sense that the "goods" that are consumed are effectively the same thing: real consumption, yet consumed at different points in time. The link between marginal utilities and satisfaction is not always so straightforward as it is in this case, and the establishment of a general relationship between satisfaction data and marginal utilities is beyond the scope of the current research. The issue here is that marginal utilities in a more general economic problem –such as the decision process over apples and oranges– are subject to normalizations (measuring goods in kilos or in ounces). "Consumption" in both periods, is logically normalized the same way in each period.

at time 1. $u(\cdot)$ is a within period utility function that is strictly concave on the positive domain. c_t is real consumption at period t. Consumption in period 1 is the numeraire good and its price is normalized to 1. Consequently, the budget constraint can be written as:

$$\begin{aligned} \mathbf{x} &= \mathrm{c}_1 + \frac{\mathrm{p}_2}{1+r_2}\mathrm{c}_2 \\ &= \mathrm{c}_1 + \frac{1}{1+r_2^*}\mathrm{c}_2 \end{aligned} \tag{2}$$

z_t is a $\mathbf{x}$ is discounted life time income. p_2 is a price index capturing the commodity price change from period 1 to period 2. r_2 and r_2^* are the nominal and the real rate of interest respectively. For expositional purposes I assume that both can be perfectly anticipated. Finally, suppose that marginal utility of consumption is *increasing* in household size, which means that there is a greater need for consumption if there are more mouths to feed. In this example I assume that $\mathrm{z}_1 < \mathrm{z}_2$.

The utility maximizing solution to this problem is well-known and boils down to allocating life time income $\mathbf{x}$ such that the following condition holds:

$$E_1\left[\frac{u_{c_2}(\mathrm{c}_2^*, \mathrm{z}_2)}{u_{c_1}(\mathrm{c}_1^*, \mathrm{z}_1)}\right] = \frac{1}{\beta(1+r_2^*)} \tag{3}$$

where u_{c_t} is the partial derivative of u with respect to consumption at period t. c_1^* and c_2^* are period t decisions on consumption that maximize utility. Because $\mathrm{z}_1 < \mathrm{z}_2$ and because marginal utility of consumption is increasing in household size, if $\beta(1+r_2^*) \approx 0$ and the utility maximizing household typically consumes more in the second period than in the first: $\mathrm{c}_1^* < \mathrm{c}_2^*$.

But how would a household that lives in a world described by the model above answer the two questions that are posed by SUSENAS? Suppose that the uncertainty in life time income $\mathbf{x}$ has materialized in such a way that the household was *just* able to satisfy basic needs like food and shelter in both periods of life. Obviously, food and shelter is equally important in both periods such that marginal utilities of consumption have been equal in both periods. In both years therefore, the household head *should* have answered affirmatively to the first question. Indeed, consumption is just adequate to satisfy the household's primary needs in the two periods of life.[14] In the second period of life, SUSENAS poses the additional question about how the "adequacy status" has changed with respect to a year ago. According to the above logic, the household head *should*[15] say, that consumption adequacy has not changed, because the household has managed to stay just adequate in both periods. Note that while adequacy stays constant, real consumption expenditures has increased over time as a result of an increase in household size. In other words, satisfying those (basic) needs required more units of $\mathbf{x}$ in the second period because there are more mouths to feed (i.e., $\mathrm{z}_1 < \mathrm{z}_2$).

If one accepts the recollected changes in food consumption adequacy as proxies of the marginal rate of substitution between today's and last year's food consumption, it offers great potential for testing the principles of the life cycle model. Using direct measurements of theoretical concepts in empirical operationalizations does not, to a large extent, depend on functional form assumptions that would otherwise frustrate empirical tests based on the Euler equation. Consequently, it narrows down the set of possible alternative hypotheses associated with a (potential) rejection. Moreover, but that is beyond the scope of this study, it provides an additional source of information that can be used to study cross sectional and intertemporal heterogeneity of preferences, an issue that is often not considered.

3 Operationalization of the test: introducing a fairly general life cycle model

In the remainder of the text I assume that changes in recollected adequacy of food consumption is a proxy for the marginal rate of substitution (MRS) of food consumption in two consecutive periods. In this research I do not specify functional forms of the within period preference functions, nor do restrict preferences to be additively separable over time. Nevertheless, I impose a clear structure on preferences to isolate a class of models that is usually referred to as life cycle models (some may have a different opinion about this). I suppose

[14] Pradhan & Ravallion (2000) show that the subjective poverty line based on this question largely coincides with the official poverty lines. This indicates that households, on average, consider themselves consumption adequate when they live above the official poverty lines

[15] The emphasis here is placed on the word *should* because in reality households may report something else.

that at period t households maximize expected utility over the life cycle subject to a lifetime budget constraint. Life time utility is an exponentially discounted sum of current and future felicity functions. (I have dropped the household i subscript for expositional purposes.)

$$\max E_t \sum_{\tau=t}^{T} \beta^{\tau-t} u_\tau \left(c_\tau\right) \tag{4}$$

Subject to the life time budget:

$$\left(1+r_{t-1}\right) A_{t-1} + y_t + \frac{y_{t+1}}{1+r_{t+1}} + \frac{y_{t+2}}{\left(1+r_{t+1}\right)\left(1+r_{t+2}\right)} + \ldots = c_t - \frac{c_{t+1}}{1+r_{t+1}} - \frac{c_{t+2}}{\left(1+r_{t+1}\right)\left(1+r_{t+2}\right)} - \ldots$$

E_t is the expectation operator, conditional on all information known to the decisionmaker at period t. E_t is short for $E\left[\cdot\middle|I_t\right]$, where I_t is the information set of the decisionmaker at period t. I use both ways of writing expectations in the paper. u_τ is the within period utility (or felicity) function. u_τ is strictly concave in c_τ, real food consumption at period τ. The τ subscript on u_τ denotes its dependence on period τ (observed and unobserved) "taste shifters". These taste shifters may include demographic variables and choice variables such as durable consumption or labor supply variables, but also lagged values of c_τ itself, to allow for durability or habits in food consumption. y_τ is real household income at period τ. r_τ is the real interest rate and β is the exponential discount rate.

For illustrative purposes I assume that within period felicity is only function of current and one period lagged food consumption. Further generalizations are possible without disrupting the main idea of the study. Furthermore, and this is only to arrive at a convenient first order condition of the problem, I assume that the within period felicities depend on lagged consumption in a specific way.

$$u_\tau \left(c_\tau\right) = \tilde{u}_\tau \left(c_\tau - \alpha c_{\tau-1}\right) \tag{5}$$

where the subscript τ in $\tilde{u}_\tau \left(c_\tau\right)$ no longer includes lagged values of consumption. It is however, still permitted to to include demographic variables for example.

The first order condition of this problem becomes:

$$E_t\big[\tilde{u}_t'(\cdot) - (1 + r_{t+1})\,\beta\tilde{u}_{t+1}'(\cdot) + \\ -\alpha\beta\tilde{u}_{t+1}'(\cdot) + \alpha(1 + r_{t+1})\,\beta^2\tilde{u}_{t+2}'(\cdot)\big] = 0 \quad (6)$$

where $\tilde{u}_\tau'(\cdot)$ is the derivative of $\tilde{u}_\tau$ w.r.t. food consumption.[16] Hayashi (1985) shows that the above optimality condition can be greatly simplified if the real rate of interest r_τ is a constant r, and T (the final period of life) is far enough in the future (also used by Dynan (2000)) [see appendix B for details].

$$E_t[MRS_{t+1}] = \frac{1}{\beta(1 + r)} \quad (8)$$

where the marginal rate of substitution between period $t + 1$ and period t consumption is defined as: $MRS_{t+1} = \frac{\tilde{u}_{t+1}'(\cdot)}{\tilde{u}_t'(\cdot)}$. Equation (8) can be rewritten as follows:

$$MRS_{t+1} = \frac{1}{\beta(1 + r)} + \varepsilon_{t+1} \quad \text{where } E_t\varepsilon_{t+1} = 0 \quad (9)$$

where ε_{t+1} is a forecast error.

Equation (8) is known as the Euler equation of consumption and implies testable restrictions on the data. Conventional approaches typically impose functional form assumptions on u_t' to estimate preference parameters and/or to test the empirical validity of that particular parameterization on the basis of consumption data. Not seldom hampered by data constraints, parametric assumptions on u_t' are highly restrictive. For example, the typical household survey exhibits limited information on the *stock* of durables. As a consequence, many authors are forced to assume that preferences over the service flows extracted from the stock of durables are separable from preferences over nondurable consumption. Such assumptions are often hard to justify and only because of practical considerations these kind of assumptions became generally accepted. Furthermore, assumptions are imposed on the curvature of the within period preference function. A widely used functional form used in this

[16]
$$\frac{\partial\tilde{u}_\tau(c_\tau - \alpha c_{\tau-1})}{\partial c_\tau} = \tilde{u}_\tau'(c_\tau - \alpha c_{\tau-1}) \times \frac{\partial(c_\tau - \alpha c_{\tau-1})}{\partial c_\tau} = \tilde{u}_\tau'(c_\tau - \alpha c_{\tau-1}) \quad (7)$$

context is the iso-elastic, or CRRA (constant relative risk aversion) utility function. Unlike the quadratic utility function, this functional form allows for a precautionary motive.

Although the CRRA utility function is arguably less restrictive than the quadratic one, its appeal is partly offset by problems in operationalizing the moment restrictions for estimating preference parameters and/or empirical testing.[17] In the CRRA case, for example, moment conditions implied by equation (8) are nonlinear in the parameters. Standard nonlinear GMM estimators that neglect the measurement error in consumption yield inconsistent parameter estimates (Amemiya 1985). Many authors therefore have resorted to (log) linear approximations of the Euler equation.[18]

In this research I do not impose such functional form assumptions, but rely on the recollection data as a direct proxy of the marginal rate of substitution in two consecutive periods (one year in this research). I assume that the recollection data relates to the MRS in the following way:[19]

$$\begin{aligned} R = 1 &\leftrightarrow \alpha_3 < MRS \\ R = 2 &\leftrightarrow \alpha_2 < MRS \leq \alpha_3 \\ R = 3 &\leftrightarrow \alpha_1 < MRS \leq \alpha_2 \\ R = 4 &\leftrightarrow \alpha_0 < MRS \leq \alpha_1 \\ R = 5 &\leftrightarrow MRS \leq \alpha_0 \end{aligned} \tag{10}$$

The relationship between the MRS and the recollection data offers scope for testing the empirical tenability of the Euler equation under general functional form specifications on the marginal rate of substitution of food consumption in two consecutive periods. There are two clear advantages with this approach. First, my approach does not rely on (hard to defend) separability assumptions on preference (e.g., the usually imposed separability assumption be-

[17]Also, the curvature of the CRRA is captured by a single parameter, hence introducing strong link between risk aversion and the intertemporal substitution elasticity.

[18]Alan, Attanasio & Browning (2009) on the other hand, emphasize some of the problems with log linearizing the Euler equation and propose alternative estimation strategies, nevertheless relying on the assumption that measurement error is "classical" (multiplicative and independent of everything).

[19]Note that the answers to the recollection questions are inversely related to the marginal rate of substitution. That is, an improvement ($R = 4, 5$) relates to low marginal rates of substitution.

tween durable and nondurable consumption, or between consumption and leisure). A rejection of the subsequent empirical tests in section (4.1) should not be due to a misrepresentation of preferences.

Second, using a directly observed proxy for the MRS might also increase the power of Euler equation based tests. “Extended life cycle models”, that allow for habits and demographics for example, may be hard to empirically distinguish from alternative theories of behavior. I consider once more the example I gave in the introduction. It is frequently observed that both consumption as well as income increase in the early phase of the life cycle. This is an apparent inconsistency with a baseline version of the life cycle model (i.e., a model that does not allow for demographics). It may subsequently be difficult to attribute this phenomenon to either changes in preferences due to demographic shifts (an “extended life cycle model”) or to more add hoc (Keynesian) consumption rules. A direct proxy of the marginal rate of substitution however, should encapsulate the demographic extension to the baseline model. Consequently, such data can be used disentangle both explanations of the empirical phenomenon. That is, if the extended life cycle model is true, food consumption adequacy should not change while consumption increases along with income. If households are Keynesian consumers, adequacy with food consumption should rise with income.

3.1 Using the proxy in an empirical test of the life cycle model

There are a few advantages of using directly observed self-reported proxies of the MRS for an empirical test of the life cycle model. Nevertheless, the definition (10) already shows that R is only a categorical proxy of the marginal rate of substitution. This fact has some consequences that I discuss in this section.

The categorical nature of the answers to the recollection questions suggests using ordered probit (or logit) routines in some way. However, these routines rely heavily on distributional assumptions on the error terms in a latent model. In our case, the latent model underlying an ordered probit model would logically be a straightforward extension of equation (9). Hence, using ordered probit routines would place heavy distributional assumptions on the forecast error itself. This is problematic as life cycle theory does not have a lot to say about the conditional distribution function of the forecast error, apart from its conditional mean, i.e., $E_t\varepsilon_{t+1} = 0$. For example, it has been suggested that the conditional variance of the forecast error may be a function of on the level of cash-on-hand[20] for, so-called, buffer stock savers [see e.g., Carroll (2001)]. Furthermore, life cycle theory certainly does not claim that the forecast error is conditionally normally distributed.

The issue here is that an ordered probit model lays down a full parametric specification of the conditional expectation function E_tR_{t+1}. For testing the predictions of the life cycle model however, we can rely on less demanding parametric specifications. In other words, some of the assumptions underlying the ordered probit model might not be necessary, particularly, normality and the constancy of the higher order conditional moments of the forecast error ε_{it+1}.

Two issues with the using the proxy call for further attention. First, the categorical nature of R, versus the continuous nature of the MRS. Second, the MRS is a cardinal concept (an MRS of 1.5 actually means something) whereas the R is ordinal.

The general question that I am interested in here is the following: is it possible to come up with a moment condition on the basis the recollection variable R that can be used to test the validity of equation (8). To answer this question it is insightful to reformulate $E_t\left[MRS_{t+1}\right]$ without loss of generality (see appendix A):[21]

$$E_t\left[MRS_{t+1}\right] = \sum_j P\left(R_{t+1} = j \middle| I_t\right) E\left[MRS_{t+1} \middle| I_t, R_{t+1} = j\right] \tag{11}$$

where $j = 0, 1, ..., J$ indicate the possible categories for R (which in my case are 5).

The difference between the expectation of the categorical variable R_{t+1} and the continuous MRS_{t+1} can be visualized as follows:

$$E_t[R_{t+1}] = \sum_{j=1}^{J} j * P\left[R_{t+1} = j | I_t\right] \tag{12}$$

$$E_t[MRS_{t+1}] = \sum_{j=1}^{J} E\left[MRS_{t+1} \middle| I_t, R_{t+1} = j\right] * P\left(R_{t+1} = j \middle| I_t\right) \tag{13}$$

[20]the sum of current income and assets

[21]Note that $E_t\left[MRS_{t+1}\right] = E\left[MRS_{t+1} \middle| I_t\right]$, where I_t is the information set of the decisionmaker.

Furthermore, if the number of categories J goes to infinity, $E\left[MRS_{t+1}\middle|I_t, R_{t+1}=j\right]$ converges to a j specific constant: $\lim_{J\to\infty} E\left[MRS_{t+1}\middle|I_t, R_{t+1}=j\right] \to c_j$.[22] As a result, we can rewrite equation (12) and (13) as follows:

$$E_t[R_{t+1}] = \sum_{j=1}^{J} j * P\left(R_{t+1}=j\middle|I_t\right) \tag{14}$$

$$E_t[MRS_{t+1}] = \sum_{j=1}^{J} c_j * P\left(R_{t+1}=j\middle|I_t\right) \tag{15}$$

As $c_1 < c_2 < ... < c_J$ there exists an monotonic mapping f such that $f(c_j) = j\ \forall j$. As a results:

$$E_t[R_{t+1}] = \sum_{j=1}^{J} f\left(c_j\right) * P\left(R_{t+1}=j\middle|I_t\right) \tag{16}$$

$$= E_t[f\left(MRS_{t+1}\right)] \tag{17}$$

The monotonic transformation of the marginal rate of substitution $f(MRS_{t+1})$ in equation (17) can be rewritten as a Taylor expansion around a constant $\alpha = \frac{1}{\beta(1+r)}$:[23]

$$E_t[R_{t+1}] = E_t[f(MRS_{t+1})] \tag{18}$$

$$= E_t\big[f(\alpha) + f'(\alpha)\left(MRS_{t+1}-\alpha\right) + \frac{1}{2}f''\left(\alpha\right)\left(MRS_{t+1}-\alpha\right)^2 + \ldots\big] \tag{19}$$

where under equation (8) we can rewrite to:

$$E_t[R_t] = f(\alpha) + f'(\alpha)E_t\varepsilon_{t+1} + \frac{1}{2}f''\left(\alpha\right)E_t\varepsilon_{t+1}^2 + \ldots \tag{20}$$

This section so far has shown that that the conditional expectation E_tR_{t+1} is a linear function of the conditional expectation of the forecast error $E_t\varepsilon_{t+1}$ *and* the conditional expectation of second and higher order conditional moments of the forecast error ε_{t+1}. Consequently,

[22]In this research the number of categories is only $J = 5$, such that the subsequent derivations are approximate for the particular case at hand.

[23]The choice of the constant is arbitrary. Yet, $\frac{1}{\beta(1+r)}$ is chosen for convenience.

a statistical rejection of the validity of $E_t\left[R_{t+1}-\phi\right]=0$ for example, where ϕ is a simple constant, does not necessarily reject the predictions of the life cycle model $E_t\varepsilon_{t+1}=0$. Additional assumptions (or additional data) are needed. In section 4 I present two series of tests. Both series are valid tests of the life cycle model under different assumptions.

4 Empirical section

So far, I have argued that the subjective recollected changes in food adequacy *should* proxy for the marginal rate of substitution of consumption in two subsequent periods. Yet, it does not mean that it actually does. Recently, many scholars recognize the added value of analyzing stated or subjective preferences data instead of, or in addition to revealed preferences data. Manski (2004) for example emphasizes the importance of measuring subjective expectations in surveys, to test or to relax the usually (maintained) assumption on rational expectations for example.

The usefulness of stated preference data in applied work however, depends for a large part on whether the data actually measures what it is supposed to measure. Kapteyn (1994) for example tests whether stated preferences data measures "the same thing" as revealed preference data and finds some differences.[24] In section (2.1) I argue that the recollected changes in consumption adequacy *should* proxy for the marginal rate of substitution of consumption in two consecutive periods. In reality however, these variables might be very noisy, or perhaps even systematically biased. At the very least the recollected changes in adequacy should be positively correlated with changes in household food consumption. Note, for example, that in a boundary case, where the recollection variables are just measuring noise, the data will be consistent with the life cycle model, thereby *spuriously* supporting the life cycle hypothesis.

To "test" whether the recollected changes measure what they are supposed to measure I have regressed the real growth rate of food consumption on five dummies representing the

[24] Also, he notes that his rejection may also be due to overly strict functional form assumptions in his empirical setup.

five answers to the recollection question:

$$\begin{aligned}\Delta \ln c_{it} &= \zeta_0 + \zeta_1 \cdot D\left(R_{it}=1\right) + \zeta_2 \cdot D\left(R_{it}=2\right) + \zeta_4 \cdot D\left(R_{it}=4\right) + \\ &\quad \zeta_5 \cdot D\left(R_{it}=5\right) \qquad (21)\end{aligned}$$

Where the $D(R=j)$ are dummies that equal 1 if $R=j$. The baseline group is the group reporting no change. I have deflated all consumption variables with region specific food poverty lines.

Table 1: Regression results: equation (21)

parameter	(1) pooled	(2) pooled	(3) FE	(4) FE
ζ_0	-0.076***	-0.076***	-0.073***	-0.073***
	(-17.55)	(-11.22)	(-10.83)	(-10.36)
ζ_1	-0.032***	-0.032*	-0.046**	-0.046
	(-2.798)	(-1.922)	(-2.006)	(-1.538)
ζ_2	0.002	0.002	0.004	0.004
	(0.205)	(0.154)	(0.236)	(0.195)
ζ_4	0.073***	0.073***	0.066***	0.066***
	(8.361)	(6.264)	(3.859)	(3.237)
ζ_5	0.131***	0.131***	0.102	0.102
	(3.310)	(2.810)	(1.249)	(1.145)
observations	17339	17339	17339	17339
R^2	0.006	0.006	0.003	0.003
F	25.19	12.14	5.404	3.535
# clusters		635		635
# groups			9619	9619

NOTE. Robust t-statistics reported in column 1 and 3. t-statistics based on clustered standard errors reported in column 2 and 4 (clustering on the village level). *** p<0.01, ** p<0.05, * p<0.1. Pooled OLS reported in column 1 and 2. Fixed effects at the household level reported in column 3 and 4.

In table (1) I estimate the parameters of equation (21) under four different assumptions on the error term. The first column are the baseline results from a simple OLS regression on equation (21). Three things can be noted here: first, the baseline group has a negative average growth rate of -0.07. Second, the group that reports $R=1$ (= deteriorated a lot) has a 3 percentage points lower growth rate than the baseline. $R = 2$ cannot be statistically distinguished from the baseline. $R = 4$ (slight improvement) on average reports a 7 percentage points higher growth rate that the baseline, and $R = 5$ (improved a lot) reports a 13 percentage points larger improvement than the baseline. These results suggest that at least on average, the subjective questions measure what they are supposed to measure (the signs of the estimates are largely correct), and the estimated coefficients are of reasonable magnitude.

Third, the R^2 of the above regression is low. About one percent of the variation in the growth rate of food consumption can be explained by these dummies. The low R^2 (in combination with highly significant parameter estimates) indicate that there is a good deal of noise in either one of the two, or both measures of change. Survey data on consumer expenditures (both in developed and in developing countries) are known to be seriously infected with measurement error. Ahmed, Brzozowski & Crossley (N.d.) estimate some properties of measurement error in recall expenditure data using the Canadian food expenditure survey. The data set combines recall and diary based expenditure data from the same households. By assuming that the diary based records are the correct ones, Ahmed, Brzozowski & Crossley (N.d.) estimate that about "70 to 80 % of the cross sectional variation in recall consumption data is measurement error". A second problem is that their evidence suggests that measurement error is negatively correlated with the true values (i.e., measurement error is not classical).

Obviously, measurement error in consumption is exacerbated when applying first differences. In our data, the standard deviation of food consumption growth is 0.4, suggesting that more than 50% of the Indonesian households face year-to-year consumption drops or rises of more than 40%. These extreme statistics should raise eyebrows and suggests the importance of measurement error. The subjective recollections, on average, seem to reflect much more reasonable figures of consumption growth [see table 1]. The difference between the average household reporting a deterioration to an improvement is around 16% per year (which is the difference in the estimated coefficients). The apparent measurement error in consumption data is another important motivation to depart from tests based on observed consumption expenditures on the predictions of the life cycle model. If measurement error is a problem one needs to account for that in one way or the other, which often concerns making assumptions about the nature of the measurement error [see e.g., Alan, Attanasio & Browning (2009) who assume that measurement errors are multiplicative, stationary and independent of everything. These assumption on the nature of the measurement error are at odds with empirical evidence (Ahmed, Brzozowski & Crossley N.d.)].

In column 2, 3 and 4 I challenge the results of column 1 by relaxing the i.i.d. assumption on the error terms. In column 2 I find roughly the same results after allowing for error dependencies within villages. Obviously, t statistics go down after this generalization. Column 3 and 4 report fixed effects (within) results on equation (21). Apart from the now insignificant ζ_5 parameter, the results do not change. Note, that the group that reports “improved a lot” is small [see figure 1]. After allowing for error dependencies within villages in column 4, the ζ_1 parameter is no longer significant. All in all, I find that the significance of the parameter estimates is not stable across columns. Yet, both the pooled results (column 1 and 2) and the fixed effects results (column 3 and 4) find a clear positive association between the recollections and changes in real food consumption. This pattern validates the empirical strategy of this research as both variables are linked, as they should be.

4.1 Testing the life cycle model

In this section I present two series of tests on the basis of the recollection questions R_{it+1}. (I reintroduce the i subscript in this section to denote households.) On the basis of equation (20) we can derive a general moment condition on the basis of R_{it+1} that relates to the moment condition implied by the life cycle model:

$$E_{it}\left[R_{it+1}\right] - \phi_{it} = f'\left(\alpha_i\right) E_{it}\left[\varepsilon_{it+1}\right] \tag{22}$$

where ϕ_{it} can be interpreted as an unknown parameter. ϕ_{it} is defined as follows:

$$\phi_{it} = f\left(\alpha_i\right) + f''\left(\alpha_i\right) E_{it}\varepsilon_{it+1}^2 + \ldots \tag{23}$$

Testing the validity of $E_{it}[\varepsilon_{it+1}] = 0$ therefore, is equivalent to testing the validity of:

$$E_{it}[R_{it+1}] - \phi_{it} = 0 \tag{24}$$

The possibility that ϕ_{it} is i and t specific however, yields considerable problems for operationalizing a test on the validity of equation (24). We basically need additional assumptions, and/or additional data on ϕ_{it} to operationalize a test on equation (24) with the available data.[25] A general test on the validity of the Euler equation on the basis of the recollections data seems not possible.

In this section I choose to impose restrictions on ϕ_{it}. In the first series of tests (table (2) column 1 and 2) I assume that ϕ_{it} is constant across households and time, hence, I test the validity of:

$$E_{it}[R_{it+1} - \phi] = 0 \tag{25}$$

A test on the basis of (25) places restrictions on the *type* of life cycle model that is tested (see 1. below).

1. $\alpha_i = \alpha$ needs to be constant across households and time. Because α is monotonically related to the discount rate, equation (25) relates to a life cycle model with constant discount rates.

In addition to the restrictions on the type of life cycle model that is tested, I also need some additional (auxiliary) assumptions on to validate the approach more generally:

2. $f(\alpha_i) \neq 0$. Otherwise the test has no power. This condition secures that there is a monotonic function that links R to the MRS.

3. The monotone transform f is linear OR higher order conditional moments of the forecast error are independent on the information set of the decisionmaker at time t, hence they are constant across households and time.

[25] In its most general appearance, where ϕ_{it} is an i and t specific unknown parameter, equation (24) cannot be generally rejected by the data.

To summarize: if both 2. and 3. holds, testing the validity of $E_{it}\left[R_{it+1}-\phi\right]=0$ is a valid test of the life cycle model with constant discount rates.

This (restrictive) model with a fixed discount rate across households and time I subsequently refer to as the *pooled model.* Equation (25) implies the following orthogonality condition:

$$E\left[\left(R_{it+1}-\phi-E\left[R_{it+1}-\phi\right]\right)'\left(x_{it}-E\left[x_{it}\right]\right)\right]=0 \tag{26}$$

Because ϕ is constant, the above can be simplified to:

$$E\left[\left(R_{it+1}-E\left[R_{it+1}\right]\right)'\left(x_{it}-E\left[x_{it}\right]\right)\right]=0 \tag{27}$$

where x_{it} is a subset of the decisionmaker's information set (i.e., $x_{it}\in I_{it}$). A logical test of the life cycle model with constant discount rates evaluates the sample equivalent of the population moment presented above, and test whether it is significantly different from zero. A way to evaluate this is by running a regression of R_{it+1} on a vector x_{it} and a constant c:

$$\textbf{pooled model:}\quad R_{it+1}=c+\gamma x_{it}+u_{it+1} \tag{28}$$

u_{it+1} is an error term. Estimation issues are discussed later on in this section.

In a next series of tests I allow the parameter ϕ_{it} to be a household specific, but constant across time:

$$E_{it}\left[R_{it+1}-\phi_i\right]=0 \tag{29}$$

Equation (23) indicates that this allows for considerably more flexibility, both of the *type* of model that is tested (i.e., household specific discount rates), but also on the restrictiveness of the auxiliary assumptions that validate the approach more generally (e.g., higher order conditional moments may be household specific constants, rather than constant across households and time). Allowing for a household specific parameter ϕ_i no longer requires discount rates to be constant across households, and hence allows for a broader class of models under the null hypothesis.

Moreover, it also allows for the possibility that households make systematic, household specific errors in answering the recollection questions. This is important as respondents may not answer the recollection question in the same way as (I suppose) they should. Where the recollections questions should reflect a *change* in food consumption adequacy, the variable might be contaminated with household specific moods. The interviewer may have interviewed the respondent on a bad or a good day (increasing the general noise levels in such measures). However, day to day changes in moods should not be correlated with important elements of the household information set, like household size, or household consumption. Consequently, it should not cause trouble in the subsequent tests. What *is* important for interpreting the outcomes is that wealthier households might be in a better mood in general, and therefore more likely to report a positive answer to any (mood related) question. Allowing for a household specific parameter ϕ_i accounts for this possible impurity in the answers to the recollection questions.

A test on the basis of (29) places restrictions on the *type* of life cycle model that is tested (see 3. below).

4. α_i is a household specific parameter. Because α_i is monotonically related to the discount rate, equation (29) relates to a life cycle model with household specific discount rates that are constant over time.

In addition, the requirements for the additional (auxiliary) assumptions to validate the approach more generally are somewhat weaker than in 2. and 3.

5. $f(\alpha_i) \neq 0$. Otherwise the test has no power. This condition secures that there is a monotonic function that links R to the MRS.

6. The monotone transform f is linear OR higher order conditional moments of the forecast error are allowed to be household specific constant. Still, they are constant over time.[26]

To summarize: if both 5. and 6. holds, testing the validity of $E_{it}[R_{it+1} - \phi_i] = 0$ is a valid test of the life cycle model with household specific discount rates.

[26]On could argue that this is problematic as the conditional variance of the forecast error is time varying for buffer-stock consumers.

I subsequently refer to the model with a household specific discount rates to as the *first difference model*. Equation (29) implies the following orthogonality condition:

$$E\left[\left(R_{it+1} - E\left[R_{it+1}\right]\right)'\left(x_{it} - E\left[x_{it}\right]\right)\right] - E\left[\left(\phi_i - E\left[\phi_i\right]\right)'\left(x_{it} - E\left[x_{it}\right]\right)\right] = 0 \qquad (30)$$

The life cycle model therefore, under the assumption of household specific constants, does not predict that R_{it+1} and x_{it} are uncorrelated. Instead, it predicts that the covariance of R_{it+1} with x_{it} is equal to the covariance of ϕ_i with x_{it}. The latter covariance term is generally non-zero. A sample equivalent of the above condition however, cannot be straightforwardly evaluated as the ϕ_i's are unobserved. The ϕ_i's need to be controlled for in some way.

The ϕ_i's can be differenced out from the baseline prediction of the life cycle model. Theory predicts $E[R_{it+1} - \phi_i | I_{it}] = 0$, but also $E[R_{it} - \phi_i | I_{it-1}] = 0$ logically. Subtracting the one from the other yields:

$$E[R_{it+1} - \phi_i | I_{it}] - E[R_{it} - \phi_i | I_{it-1}] = E[R_{it+1} | I_{it}] - E[R_{it} | I_{it-1}] = 0 \qquad (31)$$

which is a "new" moment condition implied by the theory, yet, this one does not depend on the unknown household specific effects. By applying the law of iterated expectations we can define a new (testable) condition:

$$E[R_{it+1} - R_{it} | I_{it-1}] = E[\Delta R_{it+1} | I_{it-1}] = 0 \qquad (32)$$

The condition implies again:

$$E[(\Delta R_{it+1} - E\left[\Delta R_{it+1}\right])'(x_{it-1} - E\left[x_{it-1}\right])] = 0 \qquad (33)$$

Again, a logical test of the life cycle model with household specific discount rates is a test on the statistical significance of the sample equivalent of the population moment presented above. I evaluate this by running a regression of ΔR_{it+1} on a vector x_{it-1} and a constant $\tilde{c}$:

$$\textbf{first difference model: } \Delta R_{it+1} = \tilde{c} + \tilde{\gamma} x_{it-1} + \tilde{u}_{it+1} \qquad (34)$$

In the subsequent sections I present the results of the pooled and the first difference model.

Before moving on to results of the tests, I wish to point to two important caveats. Both issues relate to the issue of approximating population moments with the associated sample equivalents. These issues have been raised before and are not specific to my approach. Nevertheless, they are important. The first issue is that we need to rely on *rational expectations* in order to secure that sample moments approach population moments in large samples [see e.g., Manski (2004) and Kapteyn, Kleinjans & Van Soest (2009) who try to relax the assumption on rational expectations using data on subjective expectations].

A second consistency issue has been raised by Chamberlain (1984). Forecast errors, average out to zero if $T \to \infty$, because of the serial independence that is implied by equation the Euler equation of consumption. Instead, Chamberlain (1984) notes that there may be "common components" in the forecast error as a result of aggregate shocks (to income for example). Consequently, forecast errors do not necessarily average out to zero if the cross sectional dimension $N \to \infty$. This is particularly problematic if those common components are correlated with the some variables in the household's information set in a cross section of households. This would be the case if, for example, wealthier households benefit more from unanticipated events (i.e., shocks) to the global economy than the poor.

Chamberlain (1984) was the first to note that where sample moments are expected to converge to the population moments if T goes to infinity, it may not converge when N, the number of households in the sample, goes to infinity. In the subsequent empirical operationalizations I allow for region specific time dummies in an attempt to filter out (at least) part of the common components in the forecast error (this approach is suboptimal as Altug & Miller (1990) for example, show that aggregate shocks are only effectively accounted for under the assumption of complete markets). In the remainder of the study I rely on N asymptotics in the sense that I assume that sample moments converge to population moments when N goes to infinity. However, with interpreting the outcomes of the tests we need to keep this possible consistency problem in mind.

4.1.1 Empirical tests of the life cycle model

I present the results of the OLS regression on the pooled model (equation (28)) and the first difference model (equation (34)) in table 2. As regressors I include the logarithm of real household consumption expenditures, and the logarithm of household size. Both variables are evaluated one period (a year in this case) before the household reported R. Further, I have included interactions of province and time dummies in an attempt to filter out aggregate components in the forecast error and to control for region specific interest rates (i.e., households in the data came from 30 Indonesian provinces[27]). The substantive results do not depend on including or excluding these dummies. Furthermore, I allow for error dependence at the village level. It is not unlikely, that unanticipated events are correlated within villages (or cities). Neglecting this correlation would lead to an overestimation of the t statistics, which might cause a spurious rejection of the life cycle model. The frequencies shown in figure (1) can be used as a baseline to interpret the marginal effects presented in column 1-3 of table (2).

Column 1 and 2 present the results of the pooled model. Both consumption and household size are (highly) significantly correlated with changes in food consumption adequacy. All else equal, wealthier households are more likely to report a positive change in adequacy. Equation (25) predicts however that wealthier households should not be significantly more likely to experience an improvement in consumption adequacy over the subsequent year. Column 3 is a validity check of the empirical approach and tests whether consumption growth is correlated with changes in adequacy (as it should).[28]

Column 4 and 5 are the results of the first difference model. Initial income is no longer significant in these regressions, a result that is consistent with the predictions of a life cycle model that allows for heterogeneity in the discount factor. On the other hand, I do find that changes in the recollection questions are positively (partially) correlated with household size. The rejection of the model with household specific discount rates is no longer related to income, yet it seems somehow related to household size. Again, column 6 reports the

[27]There are 30 provinces, 286 districts, 636 subdistricts, 659 villages in the data.

[28]related to the issue described in section 4.

Table 2: Results: pooled + first difference

VARIABLES	(1) pooled	(2) pooled	(3) pooled	(4) first diff.	(5) first diff.	(6) first diff.
ln real tc $t-1$	0.194***	0.262***				
	(10.22)	(10.61)				
ln h.h. size $t-1$		-0.145***				
		(-6.461)				
Δln real fc			0.129***			
			(5.381)			
ln real tc $t-2$				0.008	-0.037	
				(0.305)	(-1.072)	
ln h.h. size $t-2$					0.096**	
					(2.570)	
Δln real fc $-$						0.091***
Δln real fc $t-1$						(3.665)
constant	2.690***	2.760***	2.810***	0.129	0.084	0.195***
	(27.81)	(28.71)	(156.4)	(1.256)	(0.824)	(8.828)
Observations	17340	17340	17339	7721	7721	7720
region×time dummies	yes	yes	no	yes	yes	no
R^2	0.066	0.070	0.004	0.016	0.017	0.003
F	6.983	7.038	28.95	1.656	1.825	13.43
# clusters	635	635	635	602	602	602

NOTE. t-statistics (in parentheses) are calculated on the basis of clustered standard errors. Standard errors are clustered at the village level (*** p<0.01, ** p<0.05, * p<0.10). Δ denotes the first difference transformation, such that $\Delta x_t = x_t - x_{t-1}$. Dependent variable: recollected change in food consumption adequacy at t: in levels (col 1-3) and first differences (col 4-6).

validity check on the empirical approach in general. The fact that the logarithm of period $t-2$ consumption does not correlate with ΔR_{it+1} in column 4 and 5, may be due to the possibility that ΔR_{it+1} just measures noise. The significant correlation between ΔR_{it+1} and Δln real $\text{fc}_{it+1} - \Delta ln$ real fc_{it} I report in column 6 indicates that it does not.[29]

At face value the results of table (2) should be interpreted as a rejection of the life cycle model (both the one with constant discount rates and the one with individual specific discount

[29]Including age, age squared, or dummies for different age groups, did not significantly improved the fit of the model and are omitted.

rates). I have not specified a specific alternative hypothesis such that the cause of the rejection is not a priori clear. In fact, the rejection may be due to a violation of one or more of the auxiliary assumptions that I have taken to arrive at the final results. In the remainder of the section I will discuss three of the potentially important auxiliary assumptions one by one. Subsequently, I discuss a fourth alternative that we are typically most interested in: a possible alternative theory of behavior. My test does not straightforwardly discriminate between the four options. However, the test greatly limits the set of alternatives associated with a rejection. By using the recollections data as a direct proxy for the marginal rate of substitution, there is no need to look for an explanation in nonseparabilities (with leisure or durables), habit formation, measurement error, or curvature issues (e.g., precautionary savings).

1. The proxy problem. The recollection data is a proxy of the marginal rate of substitution, but it is not the same [see section (3.1) for a discussion]. The reason for writing this paper is that subjective data in general, and the recollection data in particular, can be used to relax some (often hard to defend) functional form assumptions on preference needed to operationalize a test on the theory. Section (3.1) however, has also identified a few problems with using the recollection data to proxy the marginal rate of substitution.

There are two obvious explanations for the positive correlation between consumption and R_{it+1} in column 1 and 2. First, wealthier household discount the future less strongly than the poor, and hence, expect adequacy of food consumption to increase at a higher rate. Second, wealthier households are more likely to *report* an improvement in food consumption adequacy whereas it merely reflects the notion that wealthy households are more likely to report something positive more generally. A comparison of the results of column 1 and 2 versus column 4 and 5 seem to suggest that wealthier households generally are more likely to report improvements. In this research we cannot distinguish between the two competing explanations. Nevertheless, the first difference approach controls for both and produces, arguably, a more appropriate test on the fundamentals of the model.

Section (3.1) identifies a number of different reasons of why the proxy does not work well in an empirical test of the life cycle model. If the transformation f is nonlinear, the consistency of the test on the basis of the proxy variable is only a valid test of the life cycle hypothesis if higher order moments of the forecast error are constant, in column 1 and 2, or household specific constants, in column 4 and 5. This may be problematic. It has been suggested that the conditional variance of the forecast error is a function of cash-on-hand (or income) for buffer-stock consumers. Buffer-stock consumers are typically inclined to consume more than current income (i.e., they are "impatient"). However, the prospect of a drop in consumption due to a binding liquidity constraint in the future, prevents them from doing so. Buffer-stock consumers therefore balance between their tendency of consuming more than current income (when cash-on-hand is high, and the risk of binding liquidity constraint in the near future is low) and their tendency to save to insure themselves against extreme drops in consumption (when cash-on-hand is low, and the risk of binding liquidity constraint in the near future is high). One can show that this mechanism produces a dependency of the conditional *variance* of the forecast error on cash-on-hand. If total consumption can be taken as a proxy for cash-on-hand, I do not find evidence for buffer-stock behavior in column 4 and 5. The fact that the tests reported in column 4 and 5 allow for household specific differences in the higher order conditional moments of the forecast error, makes is far less clear why the conditional variance of the forecast error would be a function of household size, simply because household size is relatively constant over time.

2. The small T, large N problem. When there are aggregate, common components in the forecast error that are not adequately controlled for by including region-time dummies, the results of table (2) are inconsistent under the null [see section (4.1) for a discussion]. Common components of the forecast error may be correlated with initial consumption in small T samples. One could think of a income shock to the global economy, such that (permanent) income of all households increases. If large households respond differently to this shock than small households, we could find correlation between household size and the recollected changes in adequacy in small T panels, even if the life cycle model is correct. This is a reasonable explanation of the results that I cannot rule out.

3. The rational expectations assumption. Only under rational expectations the sample moments converge to population moments in large samples. The assumption of rational expectations is a strong one however. It is not unlikely that households make systematic errors when maximizing expected life time utility. As a result, their *subjective* expectation of future states of the world (say their future income or of their own future preferences), do not match their empirical counterparts on average. The significant parameter estimate with household size in column 5 may reflect a failure of rational expectations. Again, if a failure of the rational expectations assumption fully accounts for the significant parameter in column 5, the life cycle model as such, should not be disqualified.

4. An alternative hypothesis of behavior. Households may not attempt to maximize expected (exponentially discounted) utility over the life cycle, but instead do something else. Households may behave more add hoc and simply adjust their consumption to current income. Also, households may be boundedly rational and maximize *some* objective function, but not the one that would maximize expected utility over the life cycle (e.g., myopic habit formation, or some naive version of hyperbolic discounting).

Many authors have been more explicit about the alternative hypothesis that is associated with a rejection of the life cycle model. The large literature on so-called "excess sensitivity" tests for example also rely on the predictions of the Euler equation, but generally have a more specific alternative hypothesis in mind. The Euler equation of consumption implies that consumption growth is uncorrelated with anticipated changes to income. Nevertheless, many empirical studies have found that that this correlation is positive and significant, thereby finding that consumption is "excessively sensitive" to income [see e.g., Browning & Lusardi (1996) for an overview]. Excess sensitivity however can be straightforwardly explained by binding liquidity constraints (for some households), or by simple add hoc consumption behavior where simply a fixed fraction of current income is consumed ("Keynesian" consumption). Both phenomena generate excess sensitivity of consumption to income.

Interpreting my results as evidence for excess sensitivity depends on a correlation between household size and anticipated changes in income. I find this unlikely. In contrast however, the fact that initial consumption is insignificant in column 4 and 5 may be even interpreted as evidence *against* excess sensitivity due to liquidity constraints. Households with binding liquidity constraints expect, almost by definition, an income increase (and a associated decrease in marginal utilities) and should be more likely to report an improvement in consumption adequacy a year later when the income increase has materialized (in expectation). Zeldes (1989) for example, argues that low wealth households are more likely to be liquidity constraint and indeed finds evidence for that hypothesis (by finding excess sensitivity of consumption growth to initial income for low wealth households only).[30] If low consumption households are indeed more likely to be liquidity constrained, they should be consequently more likely to report an improvement in adequacy. My findings therefore do not endorse the importance of liquidity constraints for low income households.

To conclude this section I would like to mention that the life cycle model with household specific discount rates, although statistically rejected, does not seem to be so bad. Both consumption levels and age variables (not reported in table (2), but available upon request) are insignificant in column 5. The household size variable is (borderline) significant with a t statistic of around 2.5. Even though the t statistics are calculated on the basis of clustered standard errors at the village level, there may be other dependencies in the error terms that are not accounted for. t statistics of around 2.5, therefore, should be considered an upper bound on some other, perhaps more appropriate t statistic that takes this dependencies into account. Consequently, t statistics of around 2.5 might not be overly convincing.

Also, I would like to point to the low R^2 in all table 2 regressions. If the life cycle model is true, the fit indeed should be low. However, the low fit can be misleading evidence in favor of the life cycle model due to measurement error in both l.h.s. and r.h.s. variables. Note that the validity check regressions in column 3 and column 6 also report low R^2's, supporting the measurement error hypothesis.

5 Conclusion

In this paper I present a new empirical test of the life cycle model. I test the orthogonality conditions implied by the Euler equation of consumption, that is, any variable available to the decisionmaker at period t, should be uncorrelated with the marginal rate of substitution

[30] Zeldes (1989) argues that income, in a group of low wealth households, is correlated with the Kuhn Tucker multiplier associated with the borrowing constraint. In high wealth groups, he argues, households are not liquidity constraint, hence, Kuhn Tucker multipliers are consequently zero.

between period $t+1$ and period t (food) consumption. This research departs from using log differences in food consumption as a proxy for this marginal rate of substitution (i.e., log linearized Euler equation), and uses "qualitative recollections of changes in food consumption adequacy" as a directly observed proxy for the marginal rate of substitution between current and last year's food consumption. The test consequently does not rely on auxiliary (and consequently arbitrary) functional form assumptions on preferences and therefore proposes a much "cleaner" test on the fundamentals of the model. I test the validity of the life cycle model that allows for habit formation (or intertemporal nonseparability more generally) and within period preference functions of unknown form (thereby allowing for nonseparabilities with durables or labor supply variables).

I use data from a consumption panel of Indonesian households drawn from the Indonesian National Socioeconomic Survey (2002-2004). Apart from the standard content of consumption surveys, households were asked to rate their household's food consumption as adequate or inadequate for their household's needs. In a followup question households were asked to rate the change in food consumption adequacy with respect to their adequacy levels a year ago, on a five point scale. In section 2.1 I argue that this variable is a proxy of the marginal rate of substitution of current over last years food consumption. Note that this proxy is only partial as the recollections variable is a categorical variable, whereas the marginal rate of substitution is continuous.

I strongly reject the life cycle model with constant discount rates. Wealthier households are more likely to report a increase in adequacy a year later. This result however, is also consistent with a general misinterpretation of the recollection data. Wealthier households, for example, may be generally more likely to report a positive answer to any "satisfaction" related question. In a second series of tests I simultaneously allow for this "reporting bias" as well as for household specific discount rates.[31] I subsequently (borderline) reject the life cycle model with household specific discount rates. The rejection of this version of the life cycle model is due to a significant correlation of the recollection data in first differences, with household size. Initial consumption and age variables are not significantly correlated with

[31] With reporting bias I mean that household's capability to judge specific is affected by moods in general.

recollection data in first differences.

Subjective data, or stated preferences data is a interesting source of information that has great potential for relaxing some of the commonly maintained assumptions in economics (e.g., rational expectations, constant preferences, etc.). Interpreting stated preferences data in relation to economic concepts however, I find, is yet in its infancy. Income satisfaction data for example, is often rather crudely taken as a measure of "utility". Much progress can be attained by studying the information content of stated preferences data. Theories (with clear predictions) need to be developed about the relationship between different types stated preferences data and on the relationship between revealed preferences data and stated preferences data. A black-and-white distinction between *experienced* utility and the utility concept that is used in demand analysis (*decision* utility), I find largely unsatisfactory [see Kahneman, Wakker & Sarin (1997) for more on this]. In this research I try to contribute to studying this link.

I have relaxed the functional form requirements usually imposed when testing the validity of the life cycle model (such that only one specific life cycle model is tested, not the model more generally). Interesting progress can be attained by thinking further about appropriate questions that relate to the intertemporal maximization problem. An interesting combination of questions could be the following: 1. How do people expect their satisfaction or adequacy with food consumption to develop over the coming year(s). 2. How do people expect their income to develop over the coming year(s). Such data would allow for a clean test on the basic principles of the life cycle model with a mere cross section of households.

A Empirical operationalization

The expectation of the MRS_{t+1} $(= \frac{u'_{t+1}}{u'_t})$ can be written as follows:

$$E_t\left[MRS_{t+1}\right] = \int_{-\infty}^{\infty} f\left(MRS_{t+1} \middle| t\right) MRS_{t+1} dMRS_{t+1} \tag{35}$$

The conditional pdf $f\left(MRS_{t+1}\middle|t\right)$ can rewritten:

$$f\left(MRS_{t+1}\middle|t\right) = \sum_j f\left(MRS_{t+1}\middle|t, R_{t+1} = j\right) \times P\left(R_{t+1} = j\middle|t\right) \tag{36}$$

Where R_{t+1} is a discrete random variable that can take on the values $j = 1, 2, 3, 4, 5$ denoting the recollected changes in adequacy.

Equation 35 and 36 can be combined:

$$\begin{aligned}
& E_t\left[MRS_{t+1}\right] \\
= & \int_{-\infty}^{\infty}\left(\sum_j f\left(MRS_{t+1}\middle|t, R_{t+1} = j\right) \times P\left(R_{t+1} = j\middle|t\right)\right) MRS_{t+1} dMRS_{t+1} \\
= & \sum_j P\left(R_{t+1} = j\middle|t\right) \int_{-\infty}^{\infty} f\left(MRS_{t+1}\middle|t, R_{t+1}\right) MRS_{t+1} dMRS_{t+1} \\
= & \sum_j P\left(R_{t+1} = j\middle|t\right) E\left[MRS_{t+1}\middle|t, R_{t+1}\right]
\end{aligned} \tag{37}$$

B Hayashi's proof

Under the assumption that $r_\tau = r \forall \tau$ rewrite equation (6) as follows:

$$E_t\left[\left((1+r)\beta\tilde{u}'_{t+1}(\cdot) - \tilde{u}'_t(\cdot)\right) - \alpha\beta\left((1+r)\beta\tilde{u}'_{t+2}(\cdot) - \tilde{u}'_{t+1}(\cdot)\right)\right] = 0 \tag{38}$$

For expositional purposes Hayashi (1985) introduces:

$$E_t y_{t+k} = E_t\left[\left((1+r)\beta\tilde{u}'_{t+k+1}(\cdot) - \tilde{u}'_{t+k}(\cdot)\right)\right] \tag{39}$$

such that equation (38) is written as:

$$E_t y_t - \alpha\beta E_t y_{t+1} = 0 \tag{40}$$

Equation (41) is supposed to hold throughout life:

$$E_s y_s - \alpha\beta E_s y_{s+1} = 0, \quad s = t, t+1, t+2, \ldots, T-1 \tag{41}$$

Taking the expectation of the above conditional on current period information:

$$E_t y_s - \alpha\beta E_t y_{s+1} = 0, \quad s = t, t+1, t+2, \ldots, T-1 \tag{42}$$

Equation (42) is a first order difference equation and can be solved by backward induction:

$$E_t y_T = \left(\frac{1}{\alpha\beta}\right)^T E_t y_t \tag{43}$$

The transversality condition prescribes that marginal utilities are not allowed to tend to infinity ("the terminal value is given" (Hayashi 1985)). Under $-1 < \alpha < 1$ and $0 \leq \beta < 1$ we must therefore conclude that $E_t y_t \to 0$ if $T \to \infty$ [this is the proof of Hayashi (1985)]. As a result we can write equation (38) as:

$$(1+r)\,\beta E_t \left[\frac{\tilde{u}'_{t+1}(\cdot)}{\tilde{u}'_t(\cdot)}\right] = 1 \tag{44}$$

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