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Abstract
The effects of poverty, independent of income, on decision-making is hypothesised to help explain persistent poverty. The link between changes in cognition and economic decision-making, while consistently identified in experimental settings, is only now emerging. Empirical evidence demonstrates that short-term cognitive ability may be consistently reduced by financial stress. Despite the identification of this link between financial stress and cognitive capacity, an explanation of the link's consequences for economic decision-making is missing from the literature. The current study uses a natural-natural experiment to help identify the effect of financial stress on household expenditure patterns via changes in cognition. Repeated measures of cognitive capacity, heuristic use and household expenditure were taken in Samburu County, Kenya following a prolonged and severe drought between November 2017 and September 2018. The outcomes of the current research through using a selected choice heuristic indicate that financial stress has direct and indirect effects on short-term cognitive capacity. Evidence is provided showing a relationship between financial stress on household expenditure. Analysis indicates that movements into and out of poverty have asymmetrical effects on economic decision-making.

Introduction

Ending global poverty is a policy objective that has both modern and historical foundations. The United Nation's Sustainable Development goals list ending global poverty first, suggesting that ending poverty is an over-riding international priority. This prioritisation also reflects growing research interest in the role of poverty as it affects aspiration setting (Dalton et al. 2015; Genicot et al. 2017) and economic decision-making (Mani et al. 2013; Carvalho et al. 2016). Earlier research focused on East Africa, among globally poor agrarian and pastoralist communities, has identified that hyperbolic discounting (Duflo et al. 2008; Duflo et al. 2011) and risk management (Lybbert et al. 2004) have important related aspects of decision-making. Duflo et al. (2011) identify two-thirds of sampled Kenyan farmers as stochastically hyperbolic with respect to fertiliser use. The greater attention given to poverty and its effects on cognitive processing of information requires further research.

A link between changes in cognition and economic decision-making is emerging. Experimental evidence indicates that cognition is strongly associated with intertemporal discounting, risk preferences and heuristic use (Kokis et al. 2002; Frederick 2005; Toplak et al. 2011; Shah et al. 2015). In particular, higher levels of cognition or intelligence are negatively associated with the use of representative, matching and gain/loss heuristics (Kokis et al. 2002). Predictors of performance on a composite rational-thinking measure were cognitive capacity and cognitive reflective test, as proposed by Frederick (2005) and expounded on by Toplak et al. (2011). These two measures were stronger predictors than measures of executive function or thinking disposition (Toplak et al. 2011). Toplak et al. (2011) argue, "Humans are cognitive misers because their basic tendency is to default to heuristic processing mechanisms of low computational expense". However, evidence of this link in non-experimental settings is limited.

Despite the identification of a plausible link between financial stress and cognitive capacity, an explanation of the consequences for economic decision-making is missing. Three immediate questions arise: i) What relative magnitude of financial stress need one experience for measurable effects on cognition to be realised; ii) What measures of cognitive capacity are most appropriate; and iii) What are the relevant domains of economic decision-making affected by possible changes in cognition? The null results of Carvalho et al. (2016) using different measures of cognition and an implicit measure of financial stress, compared to Mani et al. (2013), indicate the need to probe these questions further.

The outcomes of the current research indicate that financial stress affects cognition and economic decision-making. Cognitive capacity and choice heuristic use are two channels that affect expenditure across selected household expenditure categories. The results presented provide a link between the causal effect of stress on short-term changes in fluid intelligence (Mani et al., 2013) and the null effect reported on food expenditure (Carvalho et al., 2016). Expenditure categories affected by cognition changes have the common characteristics of uncertain and delayed returns. Moreover, the analysis indicates that movements into and out of poverty have asymmetrical effects on economic decision-making.

Individuals' cognitive capacity at any given time may be affected by a range of stressors. Sleep deprivation and other physical stressors have well-documented effects on cognitive ability to reason (Williams et al. 1959; Curcio et al. 2006; Rasch et al. 2013). Anxiety, as an aversive emotional and motivational state occurring in threatening circumstances, is an additional form of stress that may reduce cognitive performance (Eysenck et al. 2007; Haushofer et al. 2014). Mullainathan and Shafir (2013) argue that perceptions of scarcity (i.e. financial and dietary) operate as a tax on cognitive capacity or short term *bandwidth*. This notion of bandwidth capacity is closely associated to the limited-capacity resource model in psychology (Kahneman 1973; Norman et al. 1975). The frequency and expected nature of household income may be an important factor in determining the magnitude of financial stress. As a consequence, the assumed stress experienced at pre-wage, as opposed to post-wage, may not be sufficiently great to cause a short-term change in cognition (Carvalho et al., 2013).

Dual-processing theory has emerged as a unifying model of information processing that uses reflective and autonomous modes of thought (i.e. System 1 and System 2) to frame human reasoning. Within this theory, intelligence is closely associated with both modes, although it is separately defined as an algorithmic mode of reasoning (Stanovich 2011). According to Stanovich (2011), inhibition and working memory act as decoupling mechanisms allowing reasoning to move from reflective to algorithmic modes. These executive functions are mechanisms to access forms of intelligence and are not forms of intelligence themselves. The distinction is important and one that has been overlooked in the economics literature. The acknowledgement that dual-processing theory encompasses more than a dichotomous conceptualization of cognition, based on processing speed, allows for greater understanding of the relationship between intelligence, executive functions and reflective decision-making.

The term cognition is understood to encompass the related, but distinct, notions of cognitive capacity and heuristic use. Cognitive capacity refers to one's ability at a given point in time to process and recall information towards a particular objective. This capacity is flexible and likely to fluctuate over time (Franconeri et al., 2013). In contrast, cognitive ability is more likely fixed (Kortte et al., 2002). Sufficiently large reductions in capacity are expected to reduce individuals' cognitive bandwidth to process and recall information. The distinction between capacity and ability is blurred when measuring both notions using the same tool (Kortte et al., 2002). Capacity is best measured by changes in cognition scores, while ability may be measured by absolute scores. In contrast, heuristic use is commonly understood as an intuitive strategy used to reduce the cognitive load of a given decision (Gigerenzer and Goldstein 1996). Simplifying a decision through heuristic use may also reflect inattention. If the complexity of a choice is related to the available cognitive capacity of an individual, then changes in cognitive capacity is an expected driver of heuristic use.

The relationship between fluid intelligence and working-memory capacity (WMC), as a measure of cognition, is a topic of debate within psychology (Ackerman et al. 2005). General intelligence is understood to consist of fluid (*gf*) and crystalised intelligence (*gc*) (Cattell 1963). Fluid intelligence is associated with abstract reasoning and non-programmed pattern recognition. In contrast, WMC is defined as one's ability to maintain and manipulate goal-relevant information in immediate memory, particularly in the face of distraction interference. At the task level, individual measures of WMC can correlate to *gf* at levels between 0.15 and 0.40. When analyzing samples with a diverse ability range among literate samples in the United States, the correlation between individuals measures of WMC and *gf* may range between 0.30 and 0.40 (Conway et al. 2002; Unsworth et al. 2005).

Current research within economics has focused on inhibition as a measure of cognition. Inhibition is defined as one's ability to consciously or unconsciously curtail a process or behaviour and is associated with the brain's executive function. The rationale for using inhibition, memory or intelligence construction of cognition is largely missing from the economics literature (Dang et al. 2015). The following tasks are often used to measure their corresponding forms of cognition: *inhibition* - numerical Stroop task (Mani et al. 2013; Carvalho et al. 2016) and flanker task (Carvalho et al. 2016); *memory* - Simon Game (Carvalho et al. 2016); *intelligence* - Ravens Progressive Matrices (RPM) (Mani et al. 2013). The rationale for the reliance on measures of executive function, from the above literature, over fluid intelligence and WMC conceptions of cognition, is unclear.

The effects of cognitive capacity on economic decision-making are dependent on the nature and context of the decision. As identified by Duflo et al. (2011), agricultural production and investment are characterised by uncertain and delayed returns. Household expenditure on fertilizer or livestock vaccinations may be influenced by hyperbolic discounting. However, the same households are likely to conceptualise expenditure on food and energy use in different ways because of their more immediate and certain returns. Because of these differences, the effect of changes in cognitive capacity should not be assumed to be equivalent across household expenditure categories.

Methods

The relationship between two constructs of cognition and economic decision-making is tested in the current study by using measures of fluid intelligence and WMC. Both measures require no minimum level of literacy to understand or complete. The use of contrasting conceptions of cognition provides insights into the relevance of each in the selected context. A short form standard RPM task—*gf*—and an adaptive Counting Span task—WMC—were used. A set of 20 RPM problems were given to respondents, and Figure A1 shows one of these problems. This subset, of the original 60 problems, is representative of the range of difficulty present in the original. Each problem is slightly more difficult than the previous problem. Additionally, a sequence of Counting Span tasks, consisting of screens containing a random spatial distribution and number of coloured shapes (squares, circles and triangles; blue, green and red), were presented, as shown in Figure A2. Respondents were asked to count the number of a given coloured shape. At the end of the sequence, the respondent was asked to recall, in order, the numbers counted (Engle et al. 1999). The number of tasks given to respondents increased as the respondent answered tasks correctly and ranged between one and five.

The ordering of the cognition tasks presented by enumerators alternated to ensure that there were no ordering effects. The rationale for using these cognition constructs and tools is that the established literature also use these constructs and tools to measure the levels of association between these constructs and tools and the high degree of accessibility for illiterate populations. Moreover, WMC is used by Fechner et al. (2018) in a series of experiments identifying different decision-making processes used when faced with an unfamiliar decision context.

The measure of choice heuristic used in this study is associated with the respondents' degree to which they reduce a commodity's relevant attributes when making a stated choice. Attribute non-attendance (ANA) is a concept introduced into applied economics through discrete choice experiments (DCEs) (Hensher 2006). Respondents answered DCE tasks related to livestock vaccination for Cattle Lung Disease (contagious bovine pleuropneumonia). The disease is well understood by the pastoralist communities. The choice tasks were unlabelled and consisted of three alternatives: A, B and Neither (see Figure A3). Each alternative was defined by four attributes (price of the vaccine, distance to access, information concerning the status of the disease risk and expected vaccine side-effects). In each choice task, the values of the attributes could vary according to the experimental design. Respondents were asked to answer six choice tasks. In three of these choice tasks, the attribute order was fixed, while the order varied in the remaining three. At the end of each choice, task respondents could nominate which, if any, attributes they chose to ignore in making their choice.

Lastly, respondents completed a recall survey. The survey contained questions related to household income, household expenditure, livestock ownership and perceptions of household financial well-being.

The analysis is framed by a series of regressions that sequentially consider the effects of exogenous stresses on cognitive capacity (eq1), heuristic use (eq2) and household expenditures (eq3). The variance of the financial stress measures occurs at the village level and the individual household level. The variable *stress_livestock* controls for household-level effects of stress among the pastoral communities and is a measure of past livestock loss relative to current herd size. The variable *stress_vegetation* uses national difference vegetation index (NDVI) data that is recorded at the village level (USGS 2019). The rain measure is fixed across all clusters and household.

$$Cognition = \beta_1 Rain_{3month} + \beta_2 Stress_{Livestock} + \beta_3 Stress_{Vegetation} + \varepsilon \quad (1)$$

$$ANA = \beta_0 + \beta_1 Cognition + \beta_2 Rain_{3month} + \beta_3 Stress_{Livestock} + \beta_4 Stress_{Vegetation} + \beta_5 Perception_{good} + \varepsilon \quad (2)$$

$$Expenditure = \beta_0 + \beta_1 ANA + \beta_2 Cognition + \beta_3 Rain_{3month} + \beta_4 Stress_{Livestock} + \beta_5 Stress_{Vegetation} + \beta_4 Income_{monthly} + \varepsilon \quad (3)$$

A first-difference estimator is used to measure the association between the change in variables. When there are two time periods, the first-difference estimator is equivalent to the fixed-effects estimator. The first-difference estimator uses an ordinary least squares approach. The estimation equation uses the form

$$(y_{it} - y_{i,t-1}) = (\mathbf{x}_{it} - \mathbf{x}_{i,t-1})'\beta + (\varepsilon_{it} - \varepsilon_{i,t-1}), \qquad t = 2,3. \quad (4)$$

The asymptotic distribution of the first-difference estimator in a short panel is given by

$$\hat{\beta}_{FD} = \left[\sum_{i=1}^{N} (\Delta\mathbf{X}_i)'(\Delta\mathbf{X}_i)\right]^{-1} \sum_{i=1}^{N} (\Delta\mathbf{X}_i)'(\Delta\mathbf{y}_i) \quad (5)$$

with a variance matrix of

$$V[\hat{\beta}_{FD}] = \left[\sum_{i=1}^{N} (\Delta\mathbf{X}_i)'(\Delta\mathbf{X}_i)\right]^{-1} \left[\sum_{i=1}^{N} (\Delta\mathbf{X}_i)' V\left[(\widehat{\Delta\varepsilon_i})'(\widehat{\Delta\varepsilon_i}) | \Delta\mathbf{X}_i\right] (\Delta\mathbf{X}_i)\right] \left[\sum_{i=1}^{N} (\Delta\mathbf{X}_i)'(\Delta\mathbf{X}_i)\right]^{-1} \quad (6)$$

Equation (6) is robust to general forms of autocorrelation and heteroscedasticity (Cameron et al. 2005).

Focusing on changes in cognition is appropriate because of the likely relationship between cognitive capacity, cognitive load and heuristic use. Assuming that the use of choice heuristics make a given decision easier, at least from the perspective of the decision-maker, a positive relationship is expected between the likelihood of using a heuristic and the perceived cognitive load of the decision (Fechner et al. 2018). Cognitive load of a decision involves both the number of attribute trade-offs associated with a decision and the cognitive capacity of the individual to process the information. To test the dynamic nature of the cognition and its effects on economic decision-making, a first-difference or fixed-effects approach is appropriate. The first-difference estimator is more efficient compared to the fixed-effects estimator when the idiosyncratic errors follow a random walk and maintain a weaker exogeneity condition. The use of a robust Hausman test for the consistency of the first-difference estimator, relative to estimates from a pooled ordinary least squares, was not performed because of the noncomparability of matrices.

Select sub-samples are used throughout the analysis because of the hypothesis that the experience of financial stress, acting as a tax on short-term cognitive capacity, is not evenly experienced across a population. Those with relatively little disposable income may be expected to experience more stress compared to those who are wealthier. The national poverty line represents a measure of the minimum amount of monthly income necessary to enable consumption of the required minimum nutritional in-take (Ravallion et al. 1991; Ravallion et al. 2009). The Kenyan rural poverty line is Kenyan Shillings 3230 per month, per individual, or USD 32. Any measure of poverty is arbitrary with respect to experiences of financial stress. Thus, the practical distinction between whether one sits above or below the poverty line is likely often minimal. The experience of cyclical poverty is common because households may repeatedly be moving in and out of poverty (Barrett et al. 2013). As such, the anxiety associated with being in poverty is likely also equivalent to the anxiety among those marginally above the poverty line. For this reason, this study uses a poverty interval based on a symmetrical threshold above and below the national Kenyan rural poverty line.

Data

The data used in this study were collected in Samburu County, Kenya. The area sampled is classified as agro-pastoralist in an arid or semi-arid environment. The principal town in the County is Maralal, which is positioned approximately 350 km north of Nairobi. Five collection points were used around Maralal covering a radius of 20 km. Respondents were invited to participate in the study by local community leaders. Each of the communities sampled had active child sponsorship programs operating through Compassion International, Kenya. Because of the relationship between local leaders and the community through the child sponsorship program, the sample is representative of relatively poor rural Kenyan households in the selected communities. A majority of respondents had a child currently in the Compassion sponsorship program. The vetting of households wishing to receive child sponsorship based on their respective financial need, by Compassion International, helps to identify relatively poor households in each of the communities.

The timing and setting of the research coincided with the end of a severe and protracted drought. Samburu County has two wet-seasons each year: March & April and October & November. Prior to the commencement of the study in the 4th quarter of 2017, Samburu County received 10 out 11 quarters of below average rainfall and seven consecutive quarters of below average rainfall (Government of Kenya 2018b). Table 1 depicts the three survey rounds as they relate to rainfall in Samburu. Round 1 was timed to coincide with the middle of the October–November rainfall, while round 2 occurred before the March–April rainfall. Round 3 occurred at the end of the August holiday season and before the October–November rainfall. Given the respondents' knowledge of the average weather patterns and the realities of the drought, the timing of data collection was aimed to capture the natural variance in respondents' perceptions of the immediate future financial well-being of their household.

[Insert Table 1]

Assuming that the sample is representative of the wider Samburu County, respective poverty measures[1] at different periods of the drought provide another measure of its severity. Kenyan government survey data collected between September 2015 and August 2016 estimates a headcount poverty measure of 75.8 percent for Samburu (Government of Kenya 2018a). The corresponding severity measure was estimated at 16.8 percent. The same poverty measures using the sample from the period from October 2017 to September 2018 are 83.6 and 47.1, respectively (see Table A1 for further comparisons). The deepening severity of the drought in the sample period reflects, in part, the income effects of losing livestock because of drought and disease for small-scale pastoralist households.

Research design and associated tools used in the study were approved by the Washington State University Institutional Review Board (#16207) and the Kenyatta National Hospital-University of Nairobi Ethics and Research Committee (P613-10/2017). The principle investigator also received a research permit from the Kenyan Government (NACOSTI/P/17/91630/19302). On average, surveys took an average of 50 minutes to complete. Consequently, wait times by some respondents were up to several hours. As a consequence, respondents received a small gift of flour, sugar and tea at the conclusion of each survey, and a basic meal was provided. The value of this gift was approximately KES 250 (USD 2.50). Prior to the first survey round, respondents were unaware of the gift. It is not believed that the gift was a motivating factor for respondents to complete the survey.

The data comprise responses from 400 individuals over three rounds. The structure of the data is summarized in Table 2. A majority of respondents completed more than one round (58%). Two responses were given by 156 individuals (39%), and 77 individuals provided three responses (19%). The single responses during the first and second rounds allow for comparison and assess whether learning effects are present in the cognition data. Table 3 presents a comparison within each round of responses given by those who completed multiple rounds and those who completed only one.

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[1] The framework from Foster, J., J. Greer and E. Thorbecke (1984). "A class of decomposable poverty measures." Econometrica: 761–766. is used. The headcount measure is $P(0) = \frac{1}{N}\sum_{i=1}^{N}\left(\frac{z-y_i}{z}\right)^0 I(y_i - z)$, and the severity measure is $P(2) = \frac{1}{N}\sum_{i=1}^{N}\left(\frac{z-y_i}{z}\right)^2 I(y_i - z)$.

[Insert Table 2]

Table 3 includes a summary of cognition and selected demographic data by the frequency of responses given. There are no indications that respondent learning while completing more than one round affected cognition scores. In the first round, the mean RPM score was 4.8 for those who ultimately completed more than the first round, while a mean score of 4.6 was recorded among those who only completed the first round. The mean scores for the Counting Span task were 7.9 (multiple responses) and 8.8 (single response). The mean count of ANA was 7.4 (multiple responses) and 7.7 (single).

[Insert Table 3]

Marginal differences are present in comparison of the gender, age and no schooling profiles of the two groups in Round One. These differences are believed to be because of the nomadic movements of herdsmen. Young men were more likely to be surveyed during the first round but absent for subsequent rounds. This difference is reflected in having a more educated, younger and more male cohort of respondents who answered once during the first round. The opposite was true in Round Two because the profile of single responses in the second round was more female, older and more likely to have no schooling. The Counting Span score is statistically different between the two cohorts at the 10 percent level. The mean Counting Span score among those giving a single response was 5.9, compared to 7.4 among those who gave multiple responses. The mean measures of RPM and ANA were not statistically different. While the absence of younger men from the sample represents a form of sample selection, the reduced influence of such individuals on household expenditure decisions limits the potential bias.

A comprehensive summary of the cognition, socio-economic and household expenditure data is presented in Table 4. This summary excludes single survey respondents. Three measures of stress account for variation across the sample. The difference between actual rainfall and the long-term average over the preceding three-months—*rain_3months*—is a constant measure across all clusters and households. The variable *stress* is the ratio of livestock deaths (measured in Food and

Agriculture Organization (FAO) units)[2] due to drought over the past 3 months over the current stock of livestock, multiplied by 100. This livestock measure of stress varies by cluster and household. The variable *stress_veg*. is a measure of the density of vegetation with use of normalized difference vegetation index (NDVI) over a one km area at each village, averaged over the two-month preceding the survey. The variation is at the cluster level. The cognition measures, presented in Table 4, indicate the presence of a floor effect whereby minimum values of zero were achieved by respondents on RPM and Counting Span tasks. The effect is expected to restrict the variance across respondents, thereby limiting the ability to differentiate within and between respondents.

Mean monthly household income is measured using self-reported estimates of the two largest sources. Among respondents, these larges sources were uniformly livestock and crops. The mean values for the three rounds were KES 1592, KES 2000 and KES 1343, respectively. The estimate of the rural Kenya poverty line is approximately KES 3230. As a result, a clear majority of respondents live below this threshold. Livestock ownership is an important store of wealth among the Samburu people. FAO livestock units provide a weighted aggregation of livestock ownership. Across the three rounds, mean livestock ownership varied between 5.0 and 4.3 FAO units, with a maximum of 37 and a minimum of 0. The variable *FAO-dro-death* reflects a self-reported estimate of the number of livestock deaths due to drought during the past 4-months. The corresponding variable *FAO-dis-death* relates to the number of livestock deaths due to disease during the past 4-months. The variables *perception_1*, *perception_2* and *perception_3* are recoded from a 5-point Likert self-assessment of household financial well-being over the past 4-months. The lowest two scores are combined in perception_1, the middle score of average is retained in perception_2, and the upper two scores are coded in perception_3. Figure A5 presents a summary of the distribution of the Likert scale.

[Insert Table 4]

Education and food have the largest mean expenditures, which decline across the three rounds. The food expenditure is KES 4,638 in Round One, KES 3,927 in Round Two and then KES 3,375

[2] FAO units (sub-Saharan Africa) = 1.1 (camel), 0.5 (cow/bull), and 0.1 (sheep/goat).

in Round Three. Education expenditure is highest at KES 2,368 in Round One and declines to KES 1,614 in Round Three. Because of the perceived lumpiness of household expenditure in education, crops and livestock, the reference period was the past 4 months. The other expenditure categories used a 2-week reference period. The figures presented in Table 4 for education, crops and livestock have been transformed to represent a 2-week period. Aggregate crop expenditure also follows a declining trend: KES 925 in Round One to KES 729 in Round Three. Expenditures for transport and energy (wood is a common cooking energy source) consumption peak in Round Two and are at their lowest levels in Round Three. The mean aggregate expenditure for transport is KES 779 in Round One, KES 823 in Round Two and KES 501 in Round Three. The corresponding values for energy are KES 254, KES 299 and KES 93. Livestock expenditure peaks in Round Two at KES 633, while in Round One and Round Three, the expenditure is KES 547 and KES 548, respectively.

Income is a poor predictor of cognitive capacity in the sample. Figure 1 plots the correlation between each cognition measure with household monthly income over those below the rural Kenyan poverty line. In the present sample, 84 percent of the respondents had monthly estimated incomes below this poverty line. This result closely reflects the 2015–16 poverty estimates for Samburu that use survey data from an early stage of the subsequent drought (see Table A1). The correlation of income to Counting Span scores is consistently higher than when using RPM scores. For both cognition measures, there is an upward movement in correlation when per person incomes are greater than KES 1500 per month. Correlation peaks for both cognition measures at the income interval KES 2000–2499. Later analysis is replicated using alternative poverty thresholds, using ± 40 % and ± 20 % poverty intervals. Results are presented in the Appendix - Figures A6 and A7. Figure A4 presents the changes in the correlation between RPM and Counting Span scores across income increments that indicates that correlation of cognition scores among ultra-poor households (income < KES 250) is negligible. Perceptions of financial well-being, both forward and backward looking are believed to be better predictors of short-term changes in cognitive capacity (Iles et al. 2019).

[Insert Figure 1]

The use of static income thresholds over time enables individuals and their households to pass in and out. There were 40 percent of respondents were in the ± 50 per cent poverty interval at least once. Also, twenty-six percent of all observations (n=183) were from individuals in this poverty threshold. The income range presented in Figure 1 accounts for 82 percent of the sample. The greater distribution of respondents at the lowest per person income range indicates that movements into and out of the ± 50 percent poverty interval tend to come from movements from very poor individuals. By comparison, the use of a ± 20 percent poverty interval captures only 13 percent of respondents and 7 percent of all observations. The use of the ± 50 percent poverty interval, for the given sample, allows for a sufficiently large sample to run quantitative analysis.

Results

Tables 5 and 6 present results of the effect of rainfall relative to the long-term average on RPM and Counting Span scores. All results use a first-difference estimator with standard errors clustered by respondent and village with a small sample size correction. Results indicate that across several sample configurations, the proceeding drought affected the RPM score, while not uniformly affecting the Counting Span score. The signs of the coefficients in Table 5 confirm that increased rainfall is associated with increased RPM.

[Insert Tables 5 and 6]

The heuristic ANA is weakly associated with changes in RPM. Table 7 presents the results from the first-difference regression with ANA as the dependent variable. The negative relationship between RPM and ANA is statistically significant at the 15 percent level among households in the ± 20 percent poverty interval. Rainfall is negatively associated with the use of ANA across all sample configurations. This negative relationship is as expected: lower rainfall and reduced cognitive capacity are expected to increase the use of choice heuristics. The inclusion of perception_3 as an independent variable regressed on ANA improved model-fit when using the full and the below poverty line (BPL) samples. In both cases, the coefficient is negative and statistically significant. This model improvement is not reflected when using poverty intervals. The perceived movement of households into better financial conditions is expected to have a negative effect on ANA use. The predictive value of illiteracy and gender on perceptions of financial well-being are highlighted in Tables A2 and A3, which present results from a random parameter ordered probit model.

[Insert Table 7]

A first-difference estimator is used to assess the direct effects of the choice heuristic, RPM, rainfall and monthly income (per capita) on six household expenditure categories. The inclusion of income introduces some endogeneity bias associated with the income parameter; however, this inclusion does affect the cognition parameter estimates, capacity and heuristic. Summaries of the results are presented in Table 8 and 9 (see Tables A4–A9 for regression output). In particular, two features of the analysis show that cognition and heuristics have more significant effects on consumption categories of education, livestock and crops compared to food, energy and transport. Within the former categories, heuristic use has a consistently negative effect on consumption. The only statistically significant variables among food, energy and transport consumption are rainfall and income, which are estimated to have positive effects on energy and transport expenditure. The sample groupings of all, BPL and ± 50 percent poverty interval enable broad comparisons across of sample subsets above and below the poverty line.

Tables 10–12 present results that assess the symmetry of the effects of cognition and choice heuristic among people moving in, out and staying in the ± 50 percent poverty interval. Table 10 presents the estimated relationship between education, livestock and crop expenditure and ANA and RPM among households who move into the poverty interval. Estimates for education and livestock show a common pattern: ANA use is statistically significant at the 10 percent level, while RPM is not. The use of the ANA heuristic has a negative effect on expenditure at the 1, 10 and 15 percent levels across all three expenditure categories. The movements in RPM and expenditure on crops are negatively related and statistically significant at the 10 percent level. The relationship between RPM and the other expenditure categories are not meaningful.

[Insert Table 10]

Among respondents remaining in the poverty interval, RPM has a positive effect on education and livestock expenditure. Table 11 presents these estimated results. These relationships are statistically significant at the 5 and 15 percent levels. The same is not true for crop expenditure. The coefficients for the ANA variable remain negative. For crop expenditure, ANA has a negative and statistically significant relationship at the 5 percent level. Among those moving out of the poverty interval (Table 12), the only parameter that is statistically significant is income (crops) at the 15 percent level.

[Insert Tables 11 and 12]

Discussion

The correlation between RPM and Counting Span scores and the effects of rainfall and livestock induced stress on each indicate that these measures of cognition are likely distinct. The correlation of the scores are similar to those of US samples using the same measures. When ultra-poor households are excluded, the correlation between the two scores is similar to the results from US studies (i.e. rho=0.2 to 0.3). The effects of rainfall and livestock inducing stress on RPM and not on Counting Span scores may be explained by their distinct functions in dual-processing theory (Stanovich 2011). This result indicates that financial stress brought on by prolonged and severe drought among pastoralist communities affects the algorithmic domain of reasoning but potentially not the decoupling mechanism of working memory. While other decoupling mechanisms could represent the channel through which the stressor affects the reasoning ability of individuals, the use of intelligence (i.e. fluid intelligence) as a representation of the effects of a stressor on the algorithmic domain of reasoning appears a better cognitive measure for empirical measurements.

A plausible explanation for why the correlation between RPM and Counting Span scores among ultra-poor households was so low relates to potential long-term effects of financial stress on cognition (Al Hazzouri et al. 2017). In contrast, the predictive effect of changes in RPM has an increased explanatory role among households who remain in the poverty thresholds between at least two rounds of data collection. Assuming that these households remained in extreme poverty for sustained periods, financial stress, along with other forms of anxiety, could have altered the relative measures of fluid intelligence and WMC.

The relatively weak relationship between ANA and RPM and the simultaneous effects of rainfall and livestock induced stress on each indicate that financial stress has a direct effect on each. As a consequence, results indicate that while there is likely a relationship between changes in cognition and increased use of choice heuristics, financial stress directly affects both. Thus, further research is required to expound on this relationship. Nonetheless, evidence provided here supports the argument that choice heuristics are an important component in assessing the relationship between financial stress and economic decision-making. The relationship identified between ANA and household expenditure does not suggest that other heuristic strategies have the same relationship. This relationship may be particularly true with respect to food expenditure. Alternative heuristics may affect food expenditure decision-making with respect to total expenditure or the selection of substitutes.

The hypothesis that the effects of financial stress are non-uniformly distributed across a population is supported by the data. The effects of financial stress on cognitive capacity is apparent across all income groupings. However, the relationship between cognition and use of the choice heuristic is greatest and most statistically significant among households closest to the poverty line. The effects of ANA and RPM appear to have a greater relationship on education expenditure among relatively wealthier households, while their effects on livestock and crop expenditure is even across income groups. Results using alternative poverty intervals indicate that the results are not an artefact of the use of arbitrary intervals.

The effects of the choice heuristic and cognitive capacity are not evident across all expenditure categories. A negative set of relationships for education, livestock and crops contrasts with no relationships for food, energy and transport. Two plausible explanations exist. First, the level of uncertainty associated with returns derived from investments in education and livestock and crop health is expected to be greater than that in the other categories. This higher uncertainty, and the associated delayed potential realisation of returns to investments, is expected to help explain the differential relationship of heuristic use and changes in short-run cognitive capacity. The distinction in the nature of the expenditure categories, and the corresponding differences in the effects of ANA and RPM, is explained by the greater cognitive load generated when needing to mentally calculate the gains of uncertain returns realised in the future (Frederick 2005; Shah et al. 2015). Second, the reduced frequency or lumpy nature of expenditure inherent in livestock and crop expenditures may also be associated with a greater cognitive load in weighing expenditure decisions. The added uncertainty of when returns to education and livestock investment may be realised compared to the same of crop investments is likely an important difference.

The identified role of changes in cognition on agriculture-related decision-making and the lack of such a relationship on food decision-making supports the earlier work of Mani et al. (2013) and Carvalho et al. (2016). In contrast, the conflicting results may be reconciled to differences in the frequency of household expenditure across agriculture and food categories and the differing degrees and timing of uncertainty associated with expected returns. The less frequent expenditure and the larger uncertainty of returns are believed to create a greater cognitive load on decision-makers. The cognitive load requires greater levels of mental effort to weigh competing expected future returns of current expenditure decisions. The addition of a suitably great stressor increases the immediate cognitive load on decision-makers, pressuring them to use a load reducing heuristic.

The distinction between household expenditure categories fits well with existing literature. However, relative changes in expenditure may also be driven by consumption smoothing patterns of behaviour and changing risk perceptions. The consistent magnitude of heuristic coefficient estimates across the education, crops and livestock expenditure categories (Figures A6 and 7) suggest that potential idiosyncrasies are limited. These estimates are further consistent with expenditure behaviour for livestock vaccinations (from a separate study), which are considered less susceptible to consumption smoothing behaviours.

The asymmetrical relationship between movements into and out of the poverty threshold provides further insight into the nature of the effects of cognitive changes on economic decision-making. The effect of ANA on expenditure among respondents moving into poverty thresholds is not inversely reflected among those moving out of the threshold in respect to apparent magnitude or statistical significance. The lack of significance of heuristic use and cognitive capacity among those leaving the poverty threshold may be a function of i) the interval being used, ii) its direction, or iii) differences in the effect of these factors on delayed expenditure. Given the distribution of respondents towards the lower ends of income, it is assumed that most movements are coming from below the poverty threshold. Cognitive changes also have a different effect on respondents who remained in the poverty threshold. The relative importance of cognitive capacity, compared to heuristic use, may be strengthened by the duration of time spent in perceived financial stress.

A limitation of the present study includes the lack of pre-drought baseline measures of cognition or heuristic use. The lack of these baseline measures creates uncertainty whether responses in Round Three sufficiently capture pre-stress conditions. The potential that data collected captures only a segment of the wider cognitive and economic changes produced by the drought may underestimate the magnitude of changes observed. As a result, the magnitude of parameter estimates should be viewed as low-bound estimates. Furthermore, the reliance on only one geographic location limits the degree of generalizability that these results may have for other contexts in terms of geography, income and employment.

Conclusion

The results from the paper indicate that short-term changes in cognition affect household expenditure in some categories such as cognition effects, include education, livestock and crops. Probable explanations include that these expenditure categories have i) high degrees of uncertainty associated with expected returns, ii) delayed returns and iii) infrequent expenditure. In contrast, the expenditure categories food, energy and transport see no corresponding effects. These results help explain the contradictory results of Mani et al. (2013) and Carvalho et al. (2016). In addition, the comparative use of fluid intelligence and WMC provides further insights explaining contrasting outcomes among ultra-poor households and those who remain in poverty for extended periods.

The predictive power of choice heuristic use is an important extension to explain the role of cognition on market choices. The strong and consistent negative effect of ANA on expenditure supports predictions from lab experiments. The results presented provide support for the explanatory role of intelligence and heuristics use in decision-making (Frederick 2005; Toplak et al. 2011). Further work is required to identify the effects of other heuristic devices in other economic decision contexts and the association of different stressors in different cognitive measures. This future work includes a reevaluation of whether Kenyan farmers are stochastically hyperbolic or cognitively hyperbolic.

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Tables

Table 1: Rainfall (mm) and survey rounds.

	2017								**2018**								
	Q2		**Q3**			**Q4**			**Q1**			**Q2**			**Q3**		
	May	June	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Rainfall	56	10	26	25	8	86	94	24	8	10	148	270	66	53	16	19	5
Diff (Rainfall - LTA)	-13	-38	-39	-39	-23	**41**	-20	-5	-7	-15	**110**	**172**	-3	**15**	-49	-45	-26

(Source: Government of Kenya, 2018)

(Round1) (Round 2) (Round3)

Table 2: Structure of data.

n	%	R1	R2	R3
94	24	1	.	.
74	19	.	1	.
51	13	1	1	.
77	19	.	1	1
28	7	1	.	1
77	19	1	1	1
400	**101**	-	-	-

Table 3: Cognition and demographic summary by round.

Variable	**Round 1** Repeat (n=157)	Single (n=92)	**Round 2** Repeat (n=206)	Single (n=74)	**Round 3** Repeat (181)
RPM	4.8	4.6	6.2	6.8	5.9
Count	7.9	8.8	7.4	5.9	5.5
ANA	7.4	7.7	5.8	5.1	7.1
No Schooling	0.66	0.62	0.69	0.75	0.66
Age	43	41	42	46	42
Female	0.53	0.36	0.49	0.56	0.50

Table 4: Data summary by round for respondents of all three rounds.

	Round 1 n=157		Round 2 n=206		Round 3 n=181	
	Mean	Min/ max.	Mean	Min/ max.	Mean	Min/ max.
Stress						
Rain_3 months (mm)	-21.5	-	-28.0	-	-82.0	-
Livestock (deaths_drought)	80.0	-203/100	65.1	-753/100	83.7	0/100
Vegetation (NDVI)	125	115/133	132	121/140	154	133/164
Cognition						
RPM	4.8	0/12	6.2	0/13	5.9	1/13
Count	7.9	0/38	7.4	0/40	5.5	0/40
ANA	7.4	0/18	5.8	0/17	7.1	0/18
Income & Assets						
Income_monthly pp (KES)	1593	0/12000	2000	0/12500	1343	0/11667
Below povertyline	0.85	-	0.78	-	0.91	-
± 50% poverty thres.	0.25	-	0.27	-	0.27	-
± 20% poverty thres.	0.06	-	0.08	-	0.09	-
FAO units	5.0	0/37	4.3	0/23.5	4.3	0/29.1
FAO-dro-death	2.6	0/37	1.0	0/18.8	0.1	0/4
FAO-dis-death	0.68	0/10	0.95	0/12.8	0.1	0/3
Perceptions of Financial Well-Being (past)						
Perception_1	0.31	0/1	0.14	0/1	0.05	0/1
Perception_2	0.48	0/1	0.67	0/1	0.74	0/1
Percpetion_3	0.22	0/1	0.17	0/1	0.20	0/1
Expenditure (KES)						
Expend_Livestock	547	0/3200	633	0/6250	548	0/6575
Expend_Crops	925	0/8750	753	0/6250	729	0/6250
Expend_Education	2368	0/18750	2354	0/12500	1614	0/18750
Expend_Food	4638	1000/60000	3927	0/30000	3375	0/25000
Expend_Transport	779	0/6000	823	0/20000	501	0/5000
Expend_Energy	254	0/7000	299	0/3500	93	0/4000

Table 5: RPM as the dependent variable

	All			Below Poverty line			Poverty Interval (± 50%)			Poverty Interval (± 20%)		
		Robust#			Robust#			Robust#			Robust#	
	Coef.	Std. Err	p-value	Coef.	Std. Err	p-value	Coef.	Std.Err	p-value	Coef.	Std.Err	p-value
Rain_previous3	0.03	0.01	0.04	0.03	0.01	0.05	0.06	0.01	<0.01	0.01	0.04	0.80
Stress_livestock	-0.01	<0.01	0.01	-0.01	<0.01	0.02	<-0.01	<0.01	0.03	<-0.01	<0.01	0.83
Stress_veg.	0.01	0.02	0.56	<0.01	0.02	0.86	0.06	0.04	0.15	-0.04	0.08	0.60
Constant	1.28	0.24	<0.01	1.44	0.37	0.02	1.37	0.72	0.13	2.95	0.48	<0.01
R^2		0.11			0.11			0.27			0.10	
N		280			234			81			22	

Note: # Clustered by respondent and village; small sample size correction used.

Table 6: Count as the dependent variable.

	All			Below Poverty line			Poverty Interval (± 50%)			Poverty Interval (± 20%)		
		Robust[#]			Robust[#]			Robust[#]			Robust[#]	
	Coef.	Std. Err	p-value	Coef.	Std. Err	p-value	Coef.	Std.Err	p-value	Coef.	Std.Err	p-value
Rain_previous3	0.03	0.03	0.36	0.01	0.04	0.79	-0.02	0.05	0.78	-0.08	0.09	0.43
Stress_livestock	-0.01	0.01	0.39	-0.01	0.02	0.42	-0.03	0.01	0.09	<-0.01	0.02	0.63
Stress_veg.	0.02	0.05	0.65	<0.01	0.05	0.92	0.04	0.10	0.73	-0.04	0.22	0.86
Constant	-0.16	1.42	0.92	-1.03	1.31	0.48	-1.54	2.08	0.50	-2.35	3.08	0.49
R^2		0.04			0.04			0.14			0.04	
N		280			234			81			22	

Note: [#] Clustered by respondent and village; small sample size correction used.

Table 7: Attribute Non-Attendance as the dependent variable.

	All			Below Poverty line			Poverty Interval (± 50%)			Poverty Interval (± 20%)		
		Robust[#]			Robust[#]			Robust[#]			Robust[#]	
	Coef.	Std. Err	p-value	Coef.	Std. Err	p-value	Coef.	Std. Err	p-value	Coef.	Std. Err	p-value
RPM	0.03	0.10	0.78	0.07	0.11	0.52	0.06	0.14	0.68	-0.57	0.31	0.13
Rain_previous3	-0.07	0.02	<0.01	-0.07	0.02	<0.01	-0.06	0.03	0.04	-0.10	0.05	0.07
Stress_livestock	<0.01	<0.01	0.44	<0.01	<0.01	0.48	<0.01	<0.01	0.09	<0.01	0.01	0.84
Stress_veg.	0.02	0.04	0.58	0.01	0.04	0.77	0.05	0.06	0.35	<-0.01	0.08	0.96
Perception_3	-1.51	0.59	0.01	-1.38	0.67	0.04	-0.35	0.84	0.69	-1.47	1.75	0.48
Constant	-2.55	0.56	<0.01	-2.21	0.66	0.02	-3.43	0.91	<0.01	-1.57	2.35	0.57
R^2		0.13			0.10			0.20			0.43	
N		279			233			81			22	

Note: [#] Clustered by respondent; small sample size correction used.

Table 8: Coefficient sign and level of significance.

	Education			Livestock			Crops		
	All	**BPL**	**± 50%**	**All**	**BPL**	**± 50%**	**All**	**BPL**	**± 50%**
ANA	-	- -	- -	- -	- -	- -	- - -	- - -	- -
RPM							- - -	- -	
Rain_3		++					-	-	
Stress									
Stress_Veg.								- -	
Inc.monthly		+ +	+ + +				+ +	+ +	
Constant									
R^2	0.04	0.07	0.16	0.09	0.04	0.08	0.11	0.15	0.16

Note: -,+ denotes negative/positive coefficient at the 10% level, --,++ denotes 5% level, ---,+++ denotes 1% level; BPL - Below Poverty Line

Table 9: Coefficient sign and level of significance.

	Food			Energy			Transport		
	All	**BPL**	**± 50%**	**All**	**BPL**	**± 50%**	**All**	**BPL**	**± 50%**
ANA									
RPM									
Rain_3				+	+				
Stress									
Stress_Veg.			-	+					
Inc.monthly		+		+ +	+ +			+	
Constant				+ + +	+ + +				
R^2	0.02	0.03	0.07	0.11	0.11	0.09	0.06	0.07	0.02

Note: -,+ denotes negative/positive coefficient at the 10% level, - -,+ + denotes 5% level, - - -,+ + + denotes 1% level; BPL - Below Poverty Line

Table 10: Household Expenditure (past 2-weeks) - movements into the ±50% poverty interval.

	Movements IN								
	Education			**Livestock**			**Crops**		
	Coef.	Std.# Err	p-value	Coef.	Std.# Err	p-value	Coef.	Std.# Err	p-value
ANA	-225.10	70.5	<0.01	-59.19	33.2	0.08	-44.48	28.2	0.12
RPM	-63.22	114.1	0.58	-4.54	31.0	0.88	-120.27	68.3	0.08
Inc.Monthly	0.39	0.1	<0.01	0.04	0.06	0.50	0.01	0.07	0.91
Constant	88.90	422.7	0.83	-151.67	202.0	0.46	273.39	206.4	0.19
R^2	0.16			0.06			0.10		
N	64			64			64		

Table 11: Household Expenditure (past 2-weeks) - remaining in the ±50 % poverty interval.

	Remain IN								
	Education			**Livestock**			**Crops**		
	Coef.	Std.# Err	p-value	Coef.	Std.# Err	p-value	Coef.	Std.# Err	p-value
ANA	-181.00	150.8	0.25	-73.19	58.0	0.22	-171.97	83.6	0.05
RPM	463.30	177.4	0.02	73.14	44.9	0.12	53.84	82.9	0.52
Inc. Monthly	-0.46	0.6	0.46	-0.07	0.12	0.57	-0.14	0.24	0.58
Constant	-888.35	517.6	0.10	-199.89	212.3	0.36	-754.91	281.7	0.02
R^2	0.33			0.17			0.27		
N	21			21			21		

Table 12: Household Expenditure (past 2-weeks) - movements out of ±50% poverty interval.

	Movements 'OUT'								
	Education			**Livestock**			**Crops**		
	Coef.	Std.# Err	p-value	Coef.	Std.# Err	p-value	Coef.	Std.# Err	p-value
ANA	-99.02	69.6	0.16	-12.18	17.8	0.50	-20.73	20.3	0.31
RPM	56.02	115.9	0.63	19.06	20.8	0.37	-21.30	31.7	0.51
Inc. Monthly	0.02	0.2	0.90	0.02	0.03	0.43	0.10	0.07	0.13
Constant	-780.95	346.8	0.03	-197.40	105.0	0.07	39.50	157.7	0.80
R^2		0.04			0.03			0.07	
N		60			60			60	

Figures

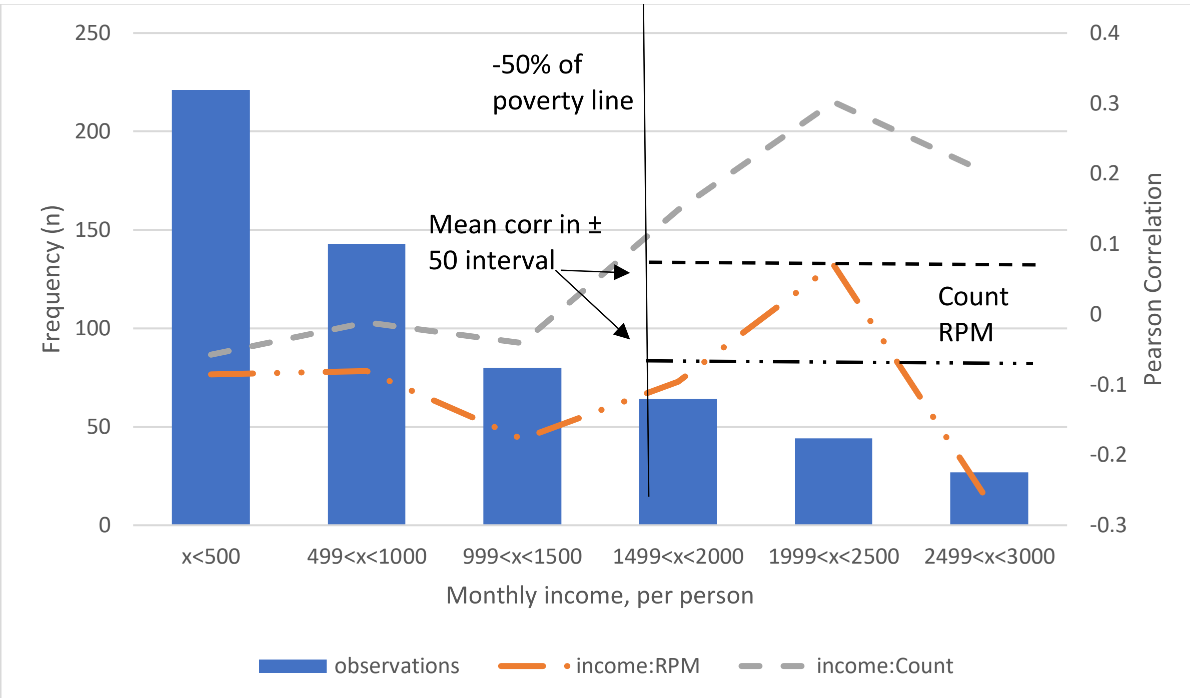


Figure 1: Correlation between household monthly income and cognition measures (RPM and Counting Span) among respondents below the poverty line.

Supplementary

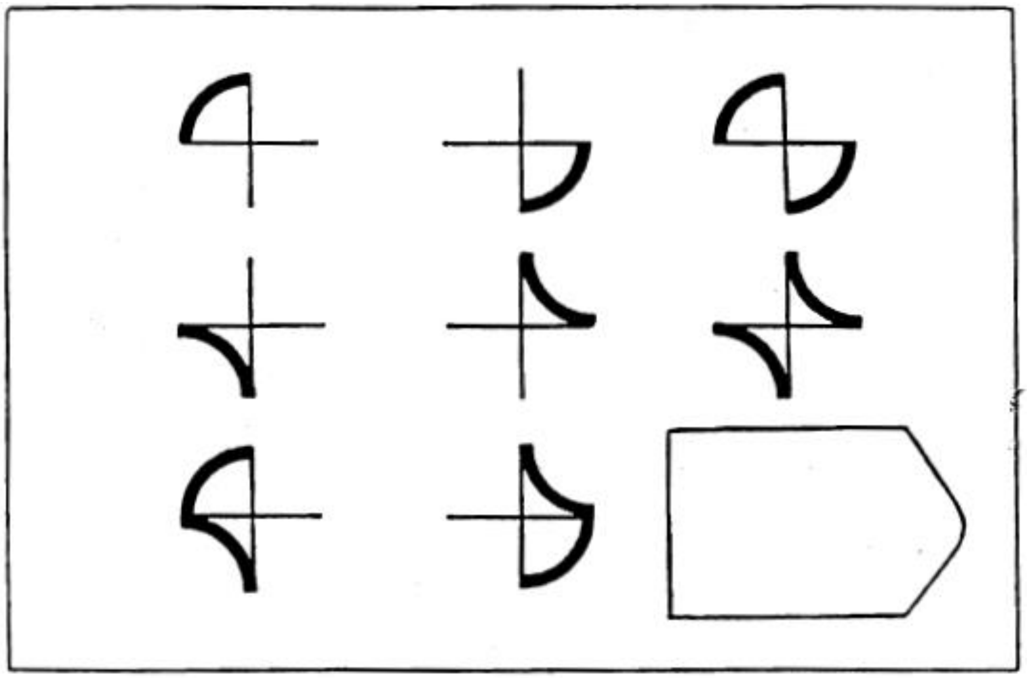


Figure A1: Ravens Progressive Matrix.

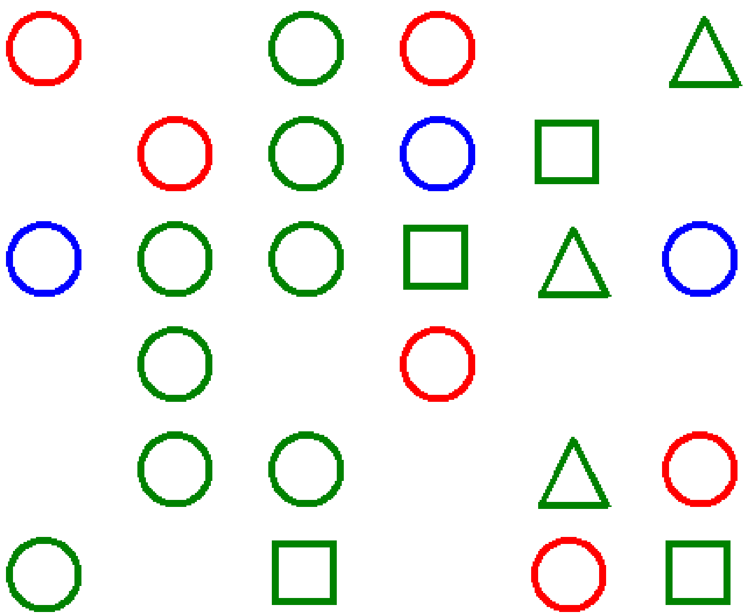


Figure A2: Counting Span task.

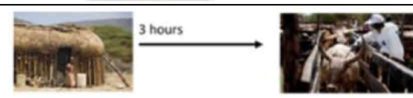
	Option A	Option B	Neither
Price			
Travel Distance			
CBPP-risk information	 (1/4'ly)	Current status	
Side-effect likelihood	 Risk Risk	 Risk Risk	

Figure A3: Discrete Choice Experiment Task display.

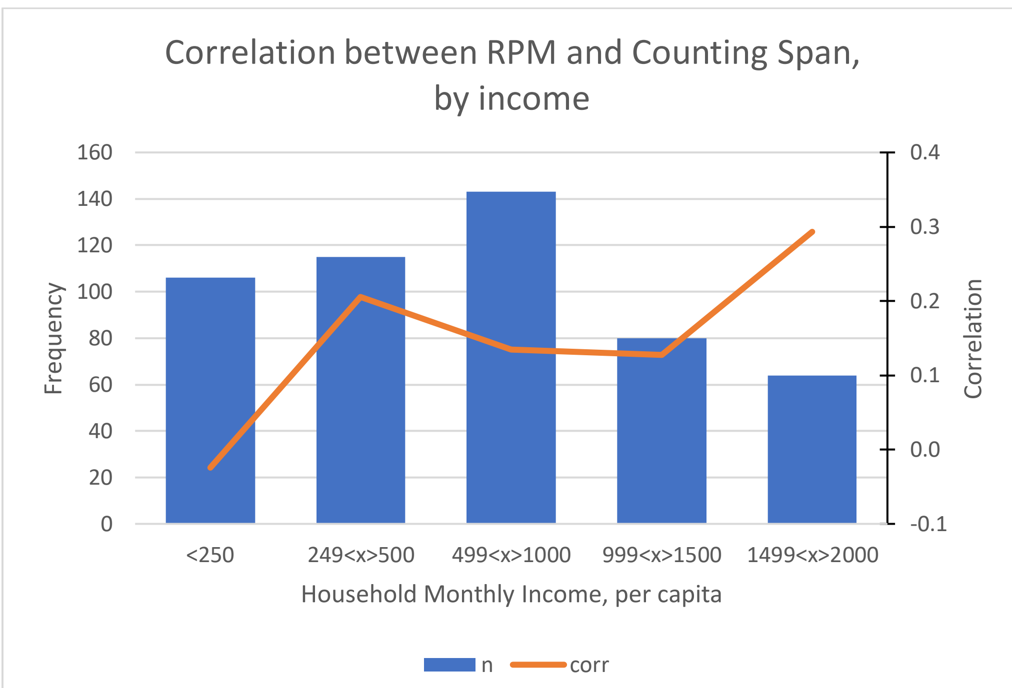


Figure A4: Correlation of RPM and Counting Span scores by monthly household income.

Random parameter ordered probit estimator was used to produce the results in Table A1 and A2. Uniform distributions were used for illiterate and female random parameters. Halton draws of 100 were used in each random parameter, which were then correlated. Table A1 presents the parameter estimates, while Table A2 presents the marginal effects. The results in A1 indicate that Rain_3 and gender are statistically significant variables. The correlation between illiteracy and gender are controlled. The marginal effects further indicate that rainfall and gender variables have statistically significant effects on respondents' perception of their households' financial well-being. Across both variables, the marginal effects for outcomes 1 and 3 had opposing signs. Women were predicted to be less likely to have poor perceptions of their well-being and more likely to have positive perceptions.

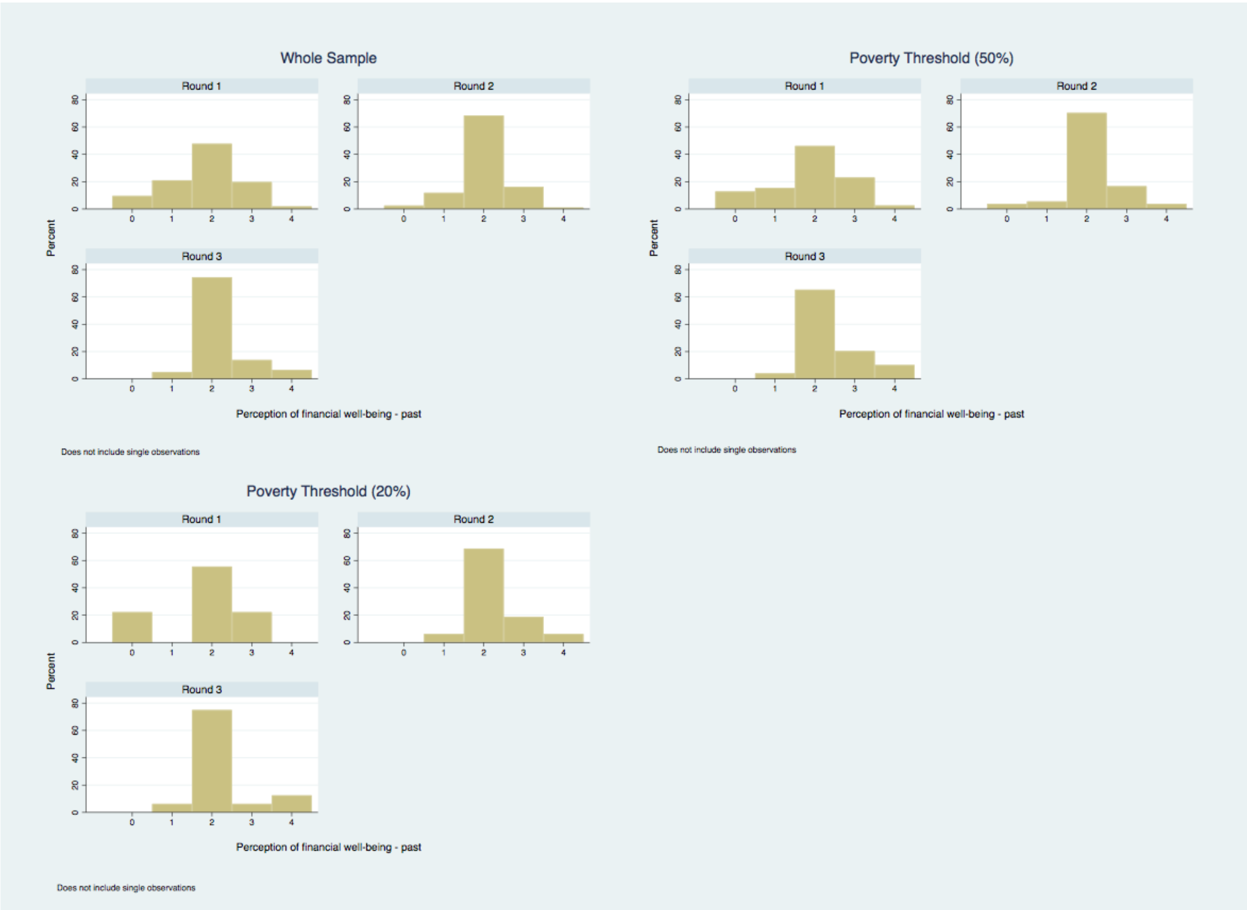


Figure A5: Histograms for respondents' perception of recent financial well-being experience over a 5-point Likert scale.

Table A1: Poverty measures for Kenya (2015–16) and Samburu (2017–18) samples.

	Headcount Rate (%)[1]	Poverty Gap[2]	Severity of Poverty (%)[3]
National	36.1	10.4	4.5
Rural	40.1	11.5	5
Peri-Urban	27.5	6.9	2.6
Urban	29.4	8.9	3.9
Samburu	**75.8**	**32.1**	**16.8**
Turkana	79.4	46.0	30.8
Marsabit	63.7	23.4	11.0
Siaya	33.8	8.7	3.5
Nairobi City	16.7	3.4	1.1
Sample (2017-18)	**83.6**	**56.2**	**47.1**

Source: (Government of Kenya 2018a)

Note: [1] Headcount Rate = $\frac{1}{N}\sum_{i=1}^{N} I(y_i - z)$, where y_i = real per capita consumption, z = poverty line and I is a binary indicator variable; [2] Poverty Gap Index = $\frac{1}{N}\sum_{i=1}^{N}\left(\frac{z-y_i}{z}\right) I(y_i - z)$ and [3] Severity of Poverty = $\frac{1}{N}\sum_{i=1}^{N}\left(\frac{z-y_i}{z}\right)^2 I(y_i - z)$

Table A2: Random parameter ordered probit of perception of financial well-being with correlated random parameters.

	All			**BPL**			**± 50%**		
	Coef.	Std Err.	p-value	Coef.	Std Err.	p-value	Coef.	Std Err.	p-value
Non-Random Parameters									
Constant	0.918	0.168	<0.001	0.907	0.187	<0.001	0.933	0.435	0.031
RPM	-0.009	0.020	0.635	-0.011	0.021	0.600	-0.005	0.044	0.916
Rain_3	-0.007	0.002	0.001	-0.008	0.002	<0.001	-0.010	0.005	0.027
Random Parameters									
Illiterate	-0.271	0.112	0.016	-0.326	0.123	0.008	-0.306	0.261	0.241
Female	0.187	0.105	0.075	0.174	0.114	0.128	0.496	0.260	0.056
Diagonal Cholesky Matrix									
Illiterate	0.762	0.150	<0.001	0.804	0.163	<0.001	1.465	0.385	<0.001
Female	0.217	0.119	0.069	0.296	0.131	0.024	0.987	0.289	<0.001
Below Diagonal Cholesky Matrix									
Fem_Illit	-1.230	0.172	<0.001	1.199	0.186	<0.001	1.653	0.407	<0.001
LL	-474.39			-394.07			-87.752		
AIC/N	1.777			1.760			1.843		

Table A3: Ordered probit (random effects) marginal effects - perception of financial well-being.

	All		BPL		± 50%	
	Effect	p-value	Coef.	p-value	Coef.	p-value
RPM						
1	0.002	0.64	0.003	0.60	<0.001	0.92
2	<0.001	0.66	<0.001	0.70	<0.001	0.92
3	-0.002	0.63	-0.003	0.60	-0.001	0.92
Rain_3						
1	0.002	<0.01	0.002	<0.01	0.001	0.04
2	<0.001	0.40	<0.001	0.64	0.001	0.24
3	-0.002	<0.01	-0.002	<0.01	-0.003	0.05
Illiterate						
1	0.057	0.01	0.068	<0.01	0.037	0.24
2	0.015	0.24	0.156	0.64	0.047	0.36
3	-0.072	0.02	-0.084	0.01	-0.084	0.27
Female						
1	-0.04	0.08	-0.039	0.13	-0.070	0.10
2	-0.006	0.43	-0.003	0.69	-0.055	0.27
3	0.047	0.08	0.042	0.13	0.125	0.07

Note: [#] **Clustered by respondent; BPL - Below Poverty Line;**

Tables A4–A9 present the results of changes in respective consumption categories, as affected by heuristics use, cognitive capacity and rainfall. The ordering of the categories reflects the aggregate mean expenditure patterns across survey rounds.

Table A4: Household Expenditure (past 2-weeks) - Food.

	Food								
	All			**BPL**			**(± 50%)**		
	Coef.	Std.# Err	p-value	Coef.	Std.# Err	p-value	Coef.	Std.# Err	p-value
ANA	52.85	66.7	0.43	36.61	75.4	0.64	-70.87	103.6	0.50
RPM	32.46	113.7	0.78	18.68	130.2	0.89	3.97	144.1	0.98
Rain_3	-6.22	20.0	0.76	1.12	21.80	0.96	-18.24	22.5	0.42
Stress_live.	1.28	2.70	0.64	1.11	2.83	0.70	0.83	3.2	0.79
Stress_veg.	-2.95	41.56	0.94	0.54	44.80	0.99	-86.12	49.8	0.09
Inc.Monthly	0.27	0.18	0.12	0.49	0.25	0.05	0.34	0.2	0.11
Constant	-786.5	855.8	0.36	-347.13	904.5	0.70	-200.47	965.9	0.84
R^2	<0.02			0.03			0.07		

Note: # Clustered by respondent; small sample correction; BPL - Below Poverty Line;

Table A5: Household Expenditure (past 2-weeks) - Education.

	Education								
	All			**BPL**			**(± 50%)**		
	Coef.	Std.# Err	p-value	Coef.	Std.# Err	p-value	Coef.	Std.# Err	p-value
ANA	-64.49	37.7	0.09	-81.56	38.2	0.04	-229.58	89.1	0.01
RPM	-6.57	57.5	0.91	-35.82	62.8	0.57	9.7	127.0	0.94
Rain_3	15.54	10.3	0.13	23.48	10.7	0.03	9.66	21.9	0.66
Stress_live.	-1.33	1.4	0.33	-1.47	1.3	0.27	-0.31	1.7	0.86
Stress_veg.	22.9	24.8	0.36	27.90	25.1	0.27	32.8	64.3	0.61
Inc.Monthly	0.10	0.07	0.14	0.17	0.09	0.05	0.35	0.1	<0.01
Constant	-35.57	371.5	0.92	308.01	409.8	0.45	-302.88	922.7	0.74
R^2	0.06			0.07			0.16		

Note: # Clustered by respondent; small sample correction; BPL - Below Poverty Line;

Table A6: Household Expenditure (past 2-weeks) - Livestock.

	Livestock								
	All			**BPL**			**(± 50%)**		
	Coef.	Std.# Err	p-value	Coef.	Std.# Err	p-value	Coef.	Std.# Err	p-value
ANA	-28.59	12.0	0.01	-27.87	13.4	0.04	-57.19	26.7	0.04
RPM	-12.15	21.8	0.58	-7.77	25.2	0.76	12.61	31.4	0.69
Rain_3	-0.61	5.1	0.91	-0.17	5.6	0.98	-0.33	7.2	0.96
Stress_live.	-0.39	0.5	0.44	-0.48	-0.5	0.36	0.55	0.6	0.36
Stress_veg.	-1.91	11.9	0.87	-4.44	12.8	0.73	-11.40	22.0	0.61
Inc.Monthly	0.02	<0.1	0.36	0.05	<0.1	0.11	0.03	<0.1	0.50
Constant	-34.07	108.4	0.75	49.48	117.0	0.67	41.43	215.6	0.85
R^2	0.03			0.04			0.08		

Note: # Clustered by respondent; small sample correction; BPL - Below Poverty Line;

Table A7: Household Expenditure (past 2-weeks) - Energy.

	Energy								
	All			BPL			(± 50%)		
	Coef.	Std.# Err	p-value	Coef.	Std.# Err	p-value	Coef.	Std.# Err	p-value
ANA	-1.95	6.2	0.75	-7.23	6.2	0.25	-2.22	14.9	0.88
RPM	-9.03	13.7	0.51	-8.70	14.2	0.54	32.25	29.5	0.28
Rain_3	4.59	2.6	0.08	4.35	2.6	0.10	1.50	3.0	0.61
Stress_live.	0.11	0.4	0.78	0.33	0.4	0.38	-0.92	0.9	0.31
Stress_veg.	-8.80	5.0	0.08	-7.79	5.3	0.14	-5.18	4.4	0.24
Inc.Monthly	0.03	<0.1	0.03	0.05	<0.1	0.01	<0.01	<0.1	0.68
Constant	255.45	72.1	<0.01	250.29	81.8	<0.01	145.28	153.9	0.35
R^2		0.11			0.11			0.09	

Note: # Clustered by respondent; small sample correction; BPL - Below Poverty Line;

Table A8: Household Expenditure (past 2-weeks) - Crops.

	Crops								
	All			BPL			(± 50%)		
	Coef.	Std.# Err	p-value	Coef.	Std.# Err	p-value	Coef.	Std.# Err	p-value
ANA	-44.38	12.9	<0.01	-59.28	13.6	<0.01	-78.81	32.6	0.01
RPM	-95.42	30.8	<0.01	-89.60	35.0	0.01	-94.49	61.1	0.13
Rain_3	-9.61	5.6	0.09	-10.68	5.8	0.07	-14.92	10.5	0.16
Stress_live.	-0.72	0.7	0.33	-0.63	0.8	0.41	0.44	1.2	0.72
Stress_veg.	-14.93	11.5	0.19	-22.47	12.2	0.07	-36.97	24.9	0.14
Inc.Monthly	0.07	<0.1	0.02	0.09	<0.1	0.03	0.07	<0.1	0.38
Constant	-111.33	162.1	0.49	20.52	162.5	0.90	90.42	315.0	0.76
R^2		0.11			0.15			0.16	

Note: # Clustered by respondent; small sample correction; BPL - Below Poverty Line;

Table A9: Household Expenditure (past 2-weeks) - Transport.

	Transport								
	All			**BPL**			**(± 50%)**		
	Coef.	Std.# Err	p-value	Coef.	Std.# Err	p-value	Coef.	Std.# Err	p-value
ANA	0.85	29.1	0.98	-6.46	31.7	0.84	-12.76	31.4	0.69
RPM	16.48	32.0	0.61	8.14	33.8	0.81	39.78	36.3	0.28
Rain_3	11.69	8.2	0.15	10.98	8.9	0.22	3.31	9.0	0.71
Stress_live.	3.42	2.3	0.14	3.53	2.5	0.16	0.33	1.0	0.73
Stress_veg.	-3.20	11.3	0.78	-4.95	11.1	0.66	10.03	13.2	0.45
Inc.Monthly	<0.01	<0.1	0.91	0.05	<0.1	0.12	-0.02	<0.1	0.66
Constant	374.22	322.0	0.25	448.59	372.4	0.23	-80.62	347.7	0.82
R^2		0.06			0.07			0.02	

Note: # Clustered by respondent; small sample correction; BPL - Below Poverty Line;

Sensitivity

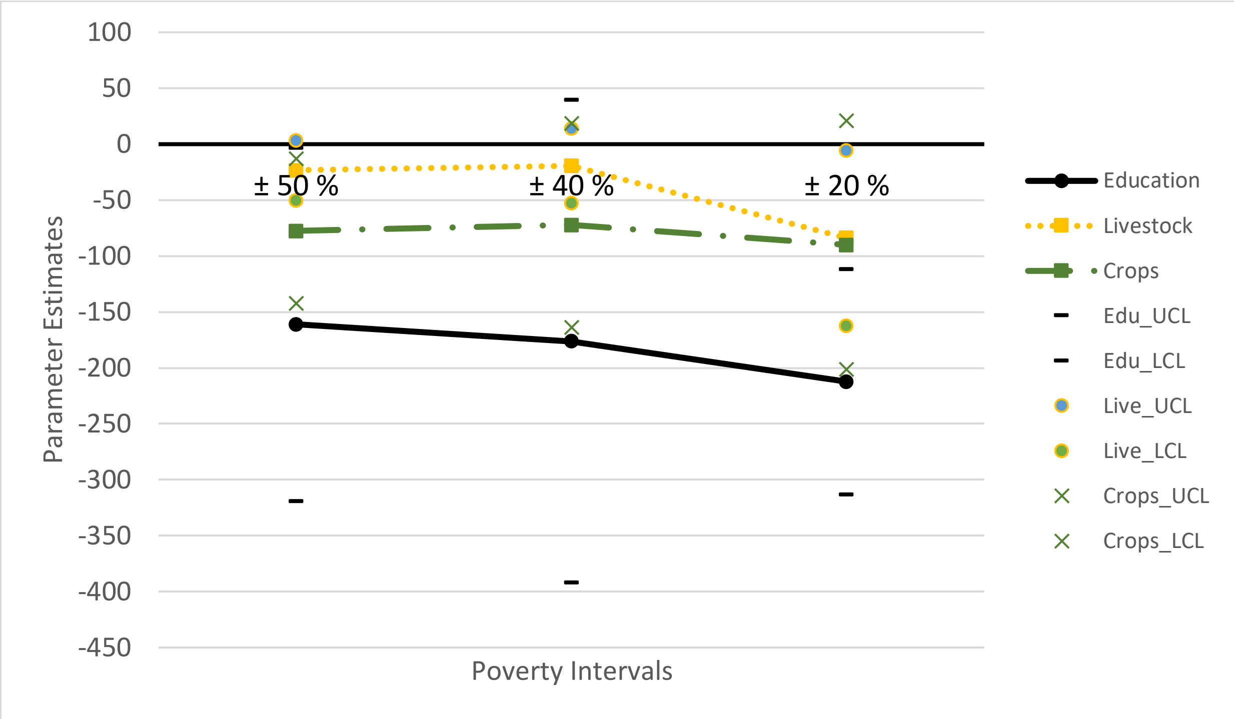


Figure A6: ANA parameter estimates based on education, livestock and crop expenditure, across alternate poverty intervals.

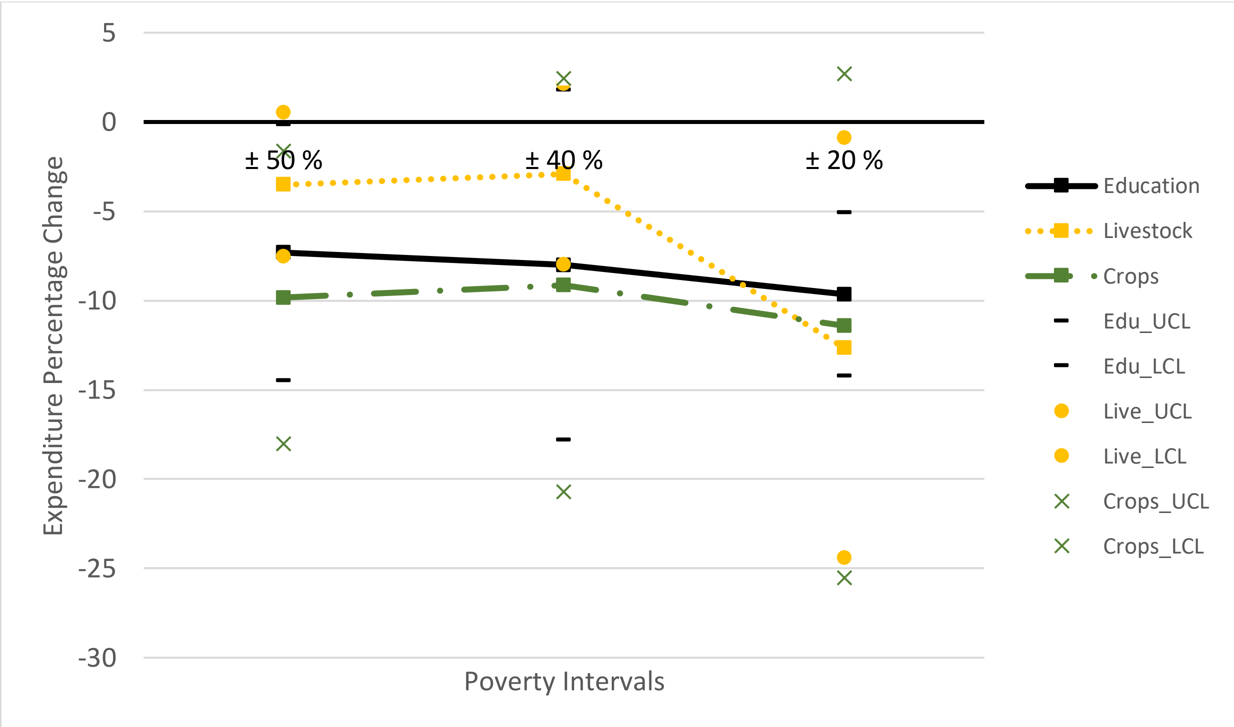


Figure A7: Converted ANA parameter estimates using percent change of expenditure based on education, livestock and crop expenditure, across alternate poverty intervals.