Can Rationality Be Taught? Experimental Evidence from India

Christopher Ksoll[1]

Annemie Maertens[2]

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Abstract

Standard utility theory builds on the concept of rational preferences, in particular a transitive and complete set of preferences. However, empirical studies have challenged these assumptions, establishing that individuals do not always behave accordingly. In this study, we use laboratory experiments in the field to document the degree of rationality among (previously) illiterate women in rural India. We find that 55% of women exhibit intransitive preferences. When making choices between lotteries, 61% violate transitivity and 32% opt for dominated gambles. We then exploit the random assignment of the women to receive an adult education program to establish the causal effect of (adult) education on rationality. We find that participation in the program decreases the probability of opting for a dominated option by 12 percentage points, or 32 percent, but does not affect preference transitivity.

[1]Corresponding author.University of Ottawa; Christopher.ksoll@uottawa.ca

[2] University of Sussex; A.Maertens@sussex.ac.uk

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1. Introduction

Standard utility theory posits that decision-makers maximize utility subject to a well-defined set of preferences that satisfy rationality axioms (Mas-Colell, Whinston, and Green 1995). In particular, a decision-maker needs to be endowed with a complete and transitive set of preferences.[3] However, an individual's preferences may fail to make choices that satisfy these underlying assumptions and axioms (Kahneman 2003).

Psychologists have in particular documented the phenomenon of preference reversal in which an individual – in a series of choices between lotteries - places the lowest monetary value on a lottery they state to prefer the least (see, among others, Liechenstein and Slovic (1971) and Grether and Plott (1979)). This phenomenon is often interpreted as violation of the transitivity assumption (even though Holt (1989) and others show that under certain conditions this phenomenon can be due to a violation of the Independence of Irrelevant Alternatives Axiom (IIAA) underlying Expected Utility Theory[4] – an arguably a less serious violation).[5]

As the transitivity assumption is key to formal choice theory, further experimental economics studies focussed on transitivity, commonly tested by presenting the subject with a series of choices in a laboratory setting. For example, Bruyneel et al. (2012), whose experimental setup we follow in our first experiment, find that 57% of school children behave in a manner that is inconsistent with transitive preferences. Violation of transitivity appears to be a common finding in these laboratory settings (Harbaugh, Krause, and Berry 2001).[6]

Transitivity of preferences is also frequently violated when choices involve risk, as in the psychologists' experiments on preferences reversal, and more recently also documented by Harbaugh, Krause and Vesterlund (2002), Burks (2009) and Choi (2014). Harbaugh, Krause and Vesterlund (2002) confront adults and children with a series of choices between a certain outcome and a simple lottery (as do we in our second experiment). They find that 38% of participants make the following type of error at least once: Opt for a low certain outcome over the lottery and, in a subsequent choice, opt for the (same) lottery over a *higher* certain outcome.

[3] Completeness means that for every pair of choices, the decision-maker prefers one choice; the other, or is indifferent. Transitivity requires that, if a decision-maker prefers choice A over B or is indifferent between A and B, and the decision-maker prefers B over C or the decision-maker is indifferent between B and C, then the decision-maker prefers A over C or A is indifferent between A and C.

[4] This axiom states that if we mix two lotteries with a third one, the preference ordering of the two resulting mixtures does not depend on the particular third lottery used.

[5] See also Karni and Safra (1987).

[6] The exception is Andreoni and Miller (2002) who find high levels of rationality among US economics degree undergraduates.

When choices involve risk, observed violations of rationality not only occur when comparing a sequence of choices (as one does when testing transitivity), but in some cases within a single choice. A classic example here is the Allais paradox (Allais 1953), an apparent violation of the IIAA. While the Allais paradox could be attributed to the complexity of the exercise, a more straightforward violation of IIAA - opting for a dominated gamble - has also been observed.[7] For instance, Engle-Warnick, Escobal, and Laszlo (2009) find that a strictly dominated gamble was chosen 25% of the time among Peruvian farmers. The psychology literature documents a similar phenomenon in a laboratory setting among undergraduate students, coined consequence monotonicity (see, among others, Von Winterfeldt et al. (1997) and Birnbaum, Paton and Lott (1999))

The prevalence of "irrational" preferences among these various populations begs the question: "What determines the degree of rationality?" Laboratory experiments among school children find that children in higher classes display increased levels of rational preferences (Harbaugh, Krause and Berry 2001; Bruyneel et al. 2012). This suggests that perhaps education itself can make us more aware of our preferences and behave in a consistent manner.[8] This ties in with Schultz's (1975) hypothesis that the value of education lies in the "ability to deal with disequilibria", specifically, to "in response to changing opportunities […] to perceive, to interpret correctly and to undertake actions that will appropriately reallocate […] resources". However, it is also be possible that children in higher classes display increased levels of preference consistency merely due to an age-related increase in cognitive ability.[9]

In this study, we use two framed laboratory experiments in the field to document the prevalence of and change in irrationality among a unique population: illiterate and newly literate women in rural India.

In the first experiment, which follows Bruyneel et al. (2012), we present the respondent with a sequence of choices over bundles of goods. Each choice consists of seven different bundles and each bundle consists of three types of cookies. Using this sequence of choices, we then determine whether the respondent's preferences are transitive. We find that 55% of women have intransitive preferences.

[7] Opting for a dominated gamble can be framed as a violation of the IIA axiom: For instance, when choosing between a lottery with a 50% chance to win 20 USD and a 50% chance to win 2 USD and a lottery of 2 USD, one should opt for gamble (under the condition that more is better than less): if 100% of 20 USD is preferred over 100% of 2 USD, then adding 50% of 2 USD to both should not alter this preference ordering.

[8] Choi et al. (2014) find higher education levels to be correlated with more rational decisions.

[9] Harbaugh, Krause and Vesterlund (2002) show that violations of transitivity are negatively correlated with age.

In the second experiment, which is modelled after Binswanger (1980) and uses a random lottery pair design (Harrison and Rutstrom 2008), we ask the respondent to make a series of choices over lotteries. For each choice, the respondent was asked to reveal their preference between a simple lottery and a certain outcome. Using this series of choices, we determine whether the respondent's observed choices violate transitivity. As in Engle-Warnick et al. (2009) we also include choices involving dominated options. We find that 61% of women violate transitivity and 32% opt for a dominated option.

We then exploit the random assignment of the women into a two-month adult education program, to establish the causal effect of (adult) education on preference rationality. Unlike the studies set in the US among school children, this adult population allows us to isolate the effect of (adult) education as opposed to merely the effect of age-related cognitive development. We find that (adult) education decreases the probability of opting for a dominated option by 12 percentage points, or 32 percent, but does not affect the probability of violating transitivity in either experiment.

Given that preference irrationality – in its worst form of choosing dominated options - is affected by a two-month adult education program one might expect larger effects for formal multi-year childhood education. This suggests that the correlations between education and rationality found by Choi et al. (2014), Harbaugh, Krause and Berry (2001) and Bruyneel et al. (2012) are due – in part at least – to education, validating Schultz' intuition (Schultz 1975).

The ability to make rational decisions is not merely of interest from a researchers' perspective but also from a policy-makers perspective. Indeed, Choi et al. (2014) find that rationality correlates with wealth. If these correlations are indication of a causal relation (as discussed in Blume and Easley 2006), then increasing the participants' ability to make rational decisions might have long term wealth consequences. Given the popularity of these types of adult education programs, these overall wealth effects might be significant.

The rest of this paper is structured as follows. In section 2, we describe the setting and data collected. Section 3 outlines the theory and empirical methodology and Section 4 presents the results. Section 5 concludes.

2. Setting and data

In 2013-14, we worked together with the NGO Development Alternatives (DA), to select a sample of 666 women in 18 villages in Sant Ravidas Nagar district in Utter Pradesh. This sample consists of all illiterate adult women between the ages of 15 and 45 who were interested in participating in an adult education program, the *Tara Akshar Literacy/Numeracy Program (TA).*As Utter

Pradesh has one of the lowest female literacy rates in India, 60% according to the 2011 Census, a significant number of women were interested in the program.

Table 1 gives an overview of the sample selection and randomization process. The sample selection proceeded in two phases. In phase I, conducted in August through October 2013, we selected a random sample of 232 illiterate women in 6 villages in which DA had already set up a literacy center and had implemented literacy classes with learners. In phase II, conducted in 2014, we selected a random sample of 431 women in 12 villages in which DA had not yet started its program activities.

We randomized both samples into a treatment and control group. The Phase I sample consisted of 97 women in the control group and 135 women in the treatment group. The Phase II sample consisted of 191 women in the control group and 240 women in the treatment group. Note that the randomization process did not follow a 50/50 division: as the number of learners per class was fixed by DA, we had to ensure that a minimum number of women were selected for the treatment group in each village.

The women in the treatment group were invited to participate in the Tara Akshar Literacy/Numeracy program within weeks of the randomization process, while the women in the control group were invited to participate at a much later date. In both phases, we conducted a survey before the TA program took place, and a survey immediately after the women in the treatment group received the TA program. In this study, we use data from both base and endline surveys.[10]

In the rest of this section, we introduce the TA program, provide an overview of the data collected and experiments conducted, and present selected descriptive statistics.

2.1. The Tara Akshar Program

The Tara Akshar (TA) program is one of three instruction methods recognized and sponsored by the Indian government under its National Literacy Mission. TA is implemented by computer-aided

[10]Note that the results of this randomization process were somewhat different in Phase I compared to Phase II. In Phase I, only 10 women who were assigned to the control group participated in the program, while only 3 women who were assigned to the treatment group did not participate in the program. In other words, most women complied with their assigned treatment status. In Phase II, however, a larger proportion of women did not comply with their treatment status, in particular, there were 64 women who were assigned to the treatment group who ended up not participating in the program. We account for non-compliance by using an instrumental variable method.

instructors in an interactive, group-based manner (10 women per group) by the NGO Development Alternatives (DA). The program builds on insights from cognitive psychology and memory tricks to teach the alphabet, e.g., the shape of the letter is turned into a cartoon that looks like the object that begins with that letter. It runs for two hours a day for 56 days and includes a numeracy component. The target population for TA is adult females between the ages of 15 and45 years in Hindi-speaking states. The program typically attracts large numbers from the historically disadvantaged Scheduled Castes (SCs) and Scheduled Tribes (STs).

2.2. Data collected

2.2.1 Household data

At baseline, we collected information on household composition and assets and conducted two tests of cognitive ability as well as a literacy and numeracy test. The numeracy test comprised of counting the number of a particular object and recognizing the numbers in numeric form. Additionally, it asks respondents to do simple mathematical observations: single-digit recognition, double digit recognition, and mathematical calculations: addition and subtraction. The literacy test includes reading Hindi letters, consonant-vowel combinations, words, nonsensical words, paragraphs in Hindi and test of comprehension of these paragraphs. The cognitive ability tests include: a) Rapid Automatic Numbering (RAN) which consists of naming the color of a series of patches as quickly as they can. This measure is assumed to tap lexical access speed and the engagement-disengagement dynamics of attention involved in reading sentences; and b) Forward Digit Span (FDS) which requires one to recall as many digits as possible and is scored out of 16. The measure is assumed to capture working memory and to play a role in reading comprehension.

In this paper, we use the RAN speed (in seconds) and the FDS score as covariates to control for baseline cognitive ability. To control for baseline literacy and numeracy we use the total numeracy score, which we call the “math score” (score out of 25) and the number of letters the respondent could recognize in one minute.

2.2.2 Experiments

In this subsection we outline the two experiments. The protocols of these experiments are included in Appendix A and B, respectively. We conducted these experiments at endline.

Risk experiment

In both Phases, we asked the respondent to make a series of 10 to 11 choices. At the end of the game one of the choices made was randomly selected and paid out in pencils, valued at 2.5 Rs each, which could be exchanged for other educational materials, such as notebooks, erasers, etc. The respondent was made aware of this payout schedule at the start of the game. However, in order to provide a realistic setting, the choices were framed in terms of kg of rice. Only one of the choices was paid out at random at the end of the game.

For each choice, the respondent was asked to reveal their preference between a gamble and a certain amount. The certain amounts selected ranged from 2 pencils to 10 pencils, in addition to 12, 14 and 18 pencils. The gamble was identical across the various choices and consisted of a 50% chance to receive 2 pencils and a 50% chance to receive 18 pencils. Hence, the expected value of the gamble is 9 pencils.

We implemented three variations of the experiment. They differed from each other in terms of the schedule and order of the sure amount they offered. Table 2 presents the game set-up. In Phase I, the sure amounts ranged from 2 to 10, in addition to 12 pencils, presented to the respondent in a semi-random order, meaning not in any particular order, but consistent across respondents. In Phase II, we implemented two versions: Schedule A and Schedule B. The respondent was presented with one of these versions, randomly selected. In Schedule A, the sure amounts included 2, 3, 5, 7, 9, 10, 12 and 18 pencils, again presented in a semi-random order. In Schedule B, the sure amounts included 3, 5, 7, 9, 10, 12, 14 and 18 pencils, this time presented in an increasing order. Appendix A provides the details of the protocol for both Phases.

We define two measures of rationality. The first measure of rationality is based on only a subset of the choices made. In particular we use the choices involving the sure amounts of 2 and 18 in Schedule A, and the sure amount of 18 in Schedule B. The respondent is considered irrational if she opts for the sure amount of 2 (as opposed to the gamble with expected value 9), or the gamble with expected value 9 over the sure amount of 18. Note that in both cases, she opts for a first order stochastically dominated lottery, which is a violation of the Independence of Irrelevant Alternatives Axiom: if reduced lottery 18 is preferred over reduced lottery 2, then adding a 50% chance of 2 to both lotteries should not change the preference relation. We note

that in Schedule A respondents might have a higher level of irrationality as they can make 2 mistakes, as opposed to Schedule B respondents who can only make one, at most. In the analysis, we will include a version fixed effect to allow for this difference, and also provide evidence on the proportion of rational choices made.

We then define a second measure of rationality, can also be constructed for Phase I respondents. In this measure, we compare sets of choices with each other and check whether the choices violate transitivity. Compare for instance Choice 2 and Choices 4 in Phase I. Imagine that in Choice 2 the respondent chooses the sure amount 3, i.e., she (weakly) prefers a sure amount of 3 over the gamble with expected value 9. In Choice 4, she prefers the gamble with expected value of 9 over the sure amount of 9. These two choices violate transitivity (under the assumption of preference monotonicity): The gamble is preferred over the value 9 and the value 3 is preferred over the gamble. Following transitivity this would imply that the value 3 is preferred over the value 9, which violates the assumption of preference monotonicity. In other words, we consider a respondent irrational if she in a descending series of "safe amounts" switches at least once from opting for the gamble to opting for the sure amount.

Goods experiment

The second experiment follows Bruyneel et al. (2012) in the experimental set-up (see also Harbaugh, Krause and Berry 2001 for a variant). In this experiment, which was identical in both phases, the respondent was presented with a sequence of nine choices, which we'll refer to as "cookie stations" (the meaning of which will soon become clear). For each station, the respondent was presented with seven options. Each option consisted of a plate of cookies. Each plate contained three distinctly different flavors of cookies: Priya Gold Butter Bite, Good Day Choco Chip and Orange Cream. The 7 options differed from each other in the amount of each cookie the plate contained. Appendix B provides the details of the protocol.

Using the sequence of 9 choices made, we define the following measure of rationality which essentially captures whether or not the respondent's choices are transitive. The following example might make this clear. Imagine the respondent opts for option 2 in the Red Station, and opts for option 3 in the Cream station. These choices represent intransitive preferences: choosing for option 2 in the Red Station implies that the respondent (weakly) prefers 3 Cookie-2 cookies over 12 Cookie-3 Cookies. Now as 12 Cookie-3 cookies are (strictly) better than 6 Cookie-3 cookies, and 4 cookie-2 cookies are (strictly) better than 3 cookie-2 (if we again assume that preferences are monotone) transitivity implies that the respondent would (strictly) choose

option 2 over option 3 in the Cream Station. Hence, choosing option 3 over option 2 (or preferring 6 cookie-3over 4 cookie-2) in the Cream Station violates transitivity.

2.3. Descriptive statistics

The first Column of Table 3 introduces the sample. The average respondent is 35 years old and has 2.77 children. Seven percent of respondents are unmarried and 4% are widowed. The remaining 89% are married.

All the women interviewed were Hindu: 8 percent of women belonged to the upper/general caste, 49.38 percent to the Other Backward Castes (OBCs) and 42.59 percent to the Scheduled Caste category. Half the women reported to be primarily doing household work, another 29 percent reported that agricultural work on their own farm is their main occupation, and about 7 percent are agricultural laborers.

We use two summary measures of wealth. The first is the Progress out of Poverty Asset Index which combines information on assets and occupation of the household.[11] The average PPI is 25. As a reference, a PPI of 20 corresponds to an about 90% chance of being under the poverty line using the international 2 USD/day/person poverty line. Hence, we can conclude that our sample of women belongs to the more marginalized section of the society in India. The second measure is an indicator variable capturing whether or not the household of the woman reports to possess a Below the Poverty Line Card[12]. 29% of the households report to own such a card.

Moving on to the test scores, the average FDS test result is 5.2 (out of a total score of 16). Recall that this test requires the respondent to recall as many digits as possible. Hence, this corresponds to recalling, on average, 5.2 numbers. On the RAN test, on average, respondents take an average time of 76.8 seconds to name colors in a series of squares as quickly she can.

The average mathematics score is 7.08 out of 35. Since three points are allocated to counting objects (with fewer than 10 individual items), 10 points for recognizing written single digits and 10 for recognizing double digit numbers, this documents the very low levels of numeracy among

[11]The PPI used for this study was created in May 2012 by Progress out of Poverty in collaboration with the Grameem Foundation and was based on data from 2009. For more information about the PPI, see www.progressoutofpoverty.org.

[12] BPL (Below Poverty Line) Ration Card is issued to those people who have annual income of less than Rs 10,000. They are entitled to get food grains and fuel at lower prices from ration shops.

the sample. Respondents are able to read, on average, 1.37 letters per minute, documenting that this is a very illiterate population at baseline.

3. Analysis and results

3.1. Theoretical Framework

We hypothesize that the adult education program, *Tara Akshar*, affects preference rationality. This could happen through different channels: as the program increases the ability to count, perhaps it increases also the ability to think through decisions which have a numerical component. Or perhaps, by increasing self-awareness, the program increases the willingness to think through decisions carefully.

We model this overall effect of the program on preference rationality in a reduced form following Rusticini (2008). Imagine a respondent has to make a decision between option A and option B. Simply speaking, she will compare the utility from Option A with the utility of Option B. We assume that if:

$$U(A) \geq U(B) \text{ (1)}$$

The respondent will opt for Option A. Now, we assume that:

$$\widetilde{U(A)} = U(A) + \varepsilon_A \text{ (2)}$$

and

$$\widetilde{U(B)} = U(B) + \varepsilon_B \text{ (3)}$$

(2) and (3) imply that the respondent's perception of what her utility is of each option depends on a her underlying ("real") preferences, captured by U(.) and an error term ε, i.e., the noise. This formulation suggests that if a respondent faces the same decision twice, she might actually make a different choice as a new random error term was drawn.

Assume that ε_A and ε_B are independent draws of the following normal distribution with variance σ.

$$\varepsilon \sim N(0, \sigma) \text{ (4)}$$

From this simple set-up, it is clear that if the variance of ε increases, the respondent is more likely to make "mistakes", meaning, more likely to choose Option A while U(B) > U (A) and vice versa.

If education reduces the variance of ε, then the quality of the decisions made increases, and the number of revealed irrational preferences would decrease. This prediction applies to all three of our measures of rationality.

3.2. Econometric specification

Assuming a successful randomization of the women into treatment and control group, we start with a simple regression specification, testing the null hypothesis of zero effect of TA on preference rationality using a Probit regression:

$$P(y_{ij} = 1) = F(\alpha + \beta\, TA_{ij} + u_j + \varepsilon_{ij}) \quad (5)$$

Where y_i denotes a binary outcome variable measuring rationality of woman i in hamlet j, TA_{ij} equals 1 if the woman belongs to the treatment group and 0 if she belongs to the control group and ε_{ij} denotes the regression error.

The lottery for participation in the TA program was implemented at the level of the hamlet (a sub-village-level), implying that for each hamlet, we divided all the candidates up in two groups: a treatment group and a control group. We follow Duflo et al. (2008) and in all regression specification add hamlet fixed effects to account for this stratification.[13] Let u_j denote the hamlet fixed effects.

Regression specification (5) results in an unbiased estimate of the average program effect if the treatment and control group are comparable at baseline.

Table 3 Columns 4 present the results of the balance test, testing differences between the treatment and control group at baseline. One can see from Table 3 that there are no statistical significant differences between the treatment and control group in terms of observable characteristics at baseline.

In a second specification, we include individual-level control variables, denoted by a vector $\boldsymbol{X_{ij}}$, including age of the respondent (in years), marriage status (married/unmarried/divorced), the number of children, the PPI score and whether the household has a BPL card (binary variable) as well as selected test results (FDS score and RAN score).

[13] In our case, including strata fixed effects is necessary to provide unbiased results, as the probability of selection into the treatment and control groups varied by lottery.

$$P(\,y_{ij} = 1) = \; F(\alpha + \; \beta\, TA_{ij} + \gamma \boldsymbol{X_{ij}} + u_j + \varepsilon_{ij})\;(6)$$

Inclusion of these control variables reduces the variance of the β coefficient estimate which might allow us to better pick up treatment effects.

Recall that not all women invited to participate in the TA program actually participated. To estimate the effect on the treated alone, we present an instrumental variable specification, instrumenting the participation status with the invitation to attend the program. In particular, we first run the following first-stage regression:

$$P_{ij} = \mathrm{F}(\alpha + \; \beta\, TA_{ij} + u_j + \varepsilon_{ij})\;(7)$$

Where P_{ij} stands for the participation status (1=participated in the TA program, 0=did not participate in the TA program). We then use the predicted participation status instead of the treatment status as main independent variable in (5) and (6), adjusting the standard errors to take into account the reduction in variance in the predicted variable.

3.3. Results

Table 4 presents the mean and variance of the outcome variables for the full sample (Column 1), the treatment group (Column 2) and the control group (Column 3). In Column (4) we report the results of a simple t-test, testing the differences between treatment and control group.

In the first experiment, the experiment in which the respondent selects a plate of cookies at various "cookie stations", 45% of the women display transitive preferences. The differences between treatment and control group are not statistically significantly different from zero. In the second experiment, the experiment in which the respondent selects lotteries, 39% of women display transitive preferences. Again, there is no statistical significant difference between treatment and control group in terms of displaying transitive preferences. In the second experiment, 68% does not opt for dominated options, or, in other words, 32% selects at a dominated option at least once. In this case, there is a difference between treatment and control group: in the treatment group 72% do not select any dominated lottery while in the control group 62% do not select any dominated lottery. This difference is statistically significant at the 5% level.

Table 5 presents the correlation coefficients between the various outcome variables: transitivity in the goods experiment, transitivity in the risk experiment, and opting for dominated choices. A positive and significant coefficient indicates a positive correlation, while a negative (and

significant) coefficient indicates a negative correlation. Overall, we find that transitivity in choices over goods and over lotteries are correlated (Top Panel), though the effect seems to arise only in the treatment group (Bottom Panel), not the control group (Middle Panel). In addition, there is a positive correlation between transitivity over goods and "Not opting for a dominated lottery" in both treatment and control group. This suggests that the two transitivity measures do capture a similar dimension of rationality. There is a positive correlation between the two measures of rationality that derive from the risk game. These measures are correlated in both the treatment and control groups.

We suggest the following interpretation: our measures of rationality are subject to two types of errors: first, an error which is due to the level of effort the respondent exerts and second, a random error, comparable to "trembling". In the control group, the error due to levels of effort has a low correlation across goods and risk choices (though there is a correlation within the two risk choices). However, in the treatment group, this part of the error term is no longer uncorrelated and as a result respondents who make rational choices over goods are also more likely to make rational choices over risk choices.

3.3.1. First stage results

To set the stage, we first review the effects of the TA program on literacy and numeracy scores. Table A1 reports on the effects of TA on various reading and mathematics scores using an instrumental variable strategy with instrument: invited to the treatment and endogenous variable: participated fully or partially in TA.

The "syllable per minute" refers to the number of Hindi letters correctly read out in 1 minute. "Grade 1 words per minute" is number one- or two-syllable words read correctly in 1 minute. "Single and double digit recognition" indicates the number of single digit and double digit correctly named. The "Mathscore" is the cumulative score of numeracy test which includes oral counting, digit identification, counting number of items, subtraction and addition problems.

Participating in TA increases all four measures of literacy and numeracy (statistically significant at the 1% to 5% level).

3.3.2. Regression results

Table 6 presents the results of regression specifications (5) and (6) using the indicator variable "preference transitivity" (1= preferences are transitive in the goods experiment; 0 = preference

violate transitivity in the goods experiment) as a dependent variable. Columns (2) through (4) present the results with controls, while Column (1) presents the results without controls. Note that the number of observations further reduces when including controls due to missing values, especially in the "age of respondent" variable: several of the respondents were unable to recall their age. Columns (1) and (2) present the results of a Probit Specification. Column (4) presents the results of an Instrumental Variable Probit Specification, instrumenting the participation status by invitation to participate in the program. Robust standard errors are included in parenthesis below the average marginal effects.

Both intent-to-treat effect as well as treatment-effect-on-the treated are not statically significantly different from zero. In terms of the correlates, being widowed seems to be associated with an increase in preference transitivity.

Table 7 presents the results of regression specifications (5) and (6) using the indicator variable "risk preference transitivity" (1= preferences are transitive in the risk experiment; 0 = preference violate transitivity in the risk experiment) as a dependent variable. Columns (2) through (4) present the results with controls, while Column (1) presents the results without controls. Columns (1) and (2) present the results of a Probit Specification. Column (4) presents the results of an Instrumental Variable Probit Specification instrumenting, instrumenting the participation status by invitation to participate in the program. Robust standard errors are included in parenthesis below the average marginal effects.

Both intent-to-treat effect as well as treatment-effect-on-the treated are not statically significantly different from zero. In terms of the additional correlates, respondents who completed the Schedule B version of the risk experiment (as opposed to the Schedule A, and Phase I version of the experiment) increases the probability of displaying transitive preferences by about 26 percentage points. Recall Table 2 (with the various schedules), this indeed makes sense, as this is the only Schedule which presented the choices in an increasing order (rather than a semi-random order).

Table 8 presents the results of regression specifications (5) and (6) using the indicator variable "opting for a dominated lottery" (1=not opting for a dominated lottery; 0 = opting for a dominated lottery) as a dependent variable. Columns (2) through (4) present the results with controls, while Column (1) presents the results without controls. Columns (1) and (2) present the results of a Probit Specification. Column (4) presents the results of an Instrumental Variable Probit Specification, instrumenting the participation status by invitation to participate in the program. Robust standard errors are included in parenthesis below the average marginal effects.

The intent-to-treat effect is estimated at 6 percentage points (statistically significant at the 5% level), implying that being invited to participate in the TA program increases one's likelihood to

not opt for a dominated lottery with, on average, 6 percentage points. The treatment-effect-on-the-treated, is, as expected, slightly higher and estimated at 12 percentage points (statistically significant at the 5% level). The Schedule A indicator variable is significantly different from zero, and large, estimated between 45 and 35 percentage points. Again, this makes sense, as Schedule A (as opposed to Schedule B) presents the choices in a semi-random order, which one can imagine, would be harder than in an increasing order.

Recall also that respondents in Schedule A can make at most two mistakes, while respondents in Schedule B can make at most one. In Table 8, we use a fixed effect to account for these differences in Schedule set-up. Appendix Table A2 analyses the effect on the proportion of rational choices. The intent-to-treat effect is estimated at 6 percentage points and the treatment-effect-on-the-treated is estimated at 10 percentage points (both are statistically significant at the 5% level).

4. Conclusion

In this study, we use a framed laboratory experiment in the field to document the degree of rationality among illiterate women in rural India. We find that 55% of women exhibit intransitive preferences with respect to choices over goods. When making choices between lotteries, 61% violate transitivity and 32% opt for dominated options. Keeping in mind the low stakes in both experiments, which might have resulted in fairly high levels of irrationality (as the respondents might have put in little effort), these levels of irrationality seem consistent with the literature to date. Bruyneel et al. (2012), in an experiment very similar to our first "cookie station" experiment, find that 57% of children behave in a manner inconsistent with transitive preferences. Harbaugh, Krause and Vesterlund (2002) find that 38% of children and adults violate transitive preferences with respect to choices over risk. Engle-Warnick, Escobal and Laszlo (2009) find that 25% of respondents in Peruvian villages choose a dominated option.

We then exploit the random assignment of these women to receive an adult education program to establish the causal program effect. We find that the program decreases the probability of opting for a dominated option by 12 percentage points (from a base of 38 percent) but does not affect preference transitivity. Intriguingly, while we do not find mean effects of the treatment on transitivity, we do find that our measures of preference transitivity in choices over goods and over risk are correlated in the treatment group – while there is no correlation in the control group.

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Appendix A: Risk Experiment Protocol

Material required-Response Sheet

[Please have enough pencils to demonstrate the two options]

Please follow the standardized language very strictly.

In this activity, we want to understand how you take decisions in your life.

First, we start with an example.

You already have all the knowledge about farming. We will talk about something related to farming. If you do not understand anything, please do stop us and clarify.

Now, think of a seed of paddy that gives you 2 kg paddy after harvesting ***for sure*****.** *You already have this seed with you.*

But, there is a new seed that gives you 1 kg paddy or 3 kg paddy.Most important thing is that before sowing the seed, there is an equal chance of both the outcomes.

The price and quality of both the seeds is the same.

Now I am showing you these pencils and in the end, your reward will be in terms of pencils, conditional on your decisions.The cost of one pencil is Rs 2.5.Think of one pencil as 1 kg paddy.

Now you tell me which seed will you prefer such that you get maximum benefit and produce.

Choice	Option 1	Option 2	Choice
1	50% **1** Kg of rice (Green) 50% **3** Kg of rice (blue)	**2** Kg of rice for sure	

Why didn't you take the other option?

Now the example is over.

You have to these decisions for some more questions.

Have a look at all these colours.(*Show them the colours on the form)*

In the end, you will choose one of these colours and get your reward in terms of pencils on the basis of colou chosen. So, I will note down your choices.

(Enumerator,do remember that in actual practice,there is going to be ONLY one drawing.For every choice that the respondent makes,just note down the choice and move ahead.You conduct the drawing using the chits only at the end)

Now tell me : Would you prefer the seed that gives you 19 kg paddy for sure or the second new seed that gives you either 2 kg or 18 kg paddy with an equal chance?

	Choice	Option 1	Option 2	Choice
Dark Green	1	50% **2** Kg of rice (Green) 50% **18** Kg of rice (blue)	**19** Kg of rice for sure	

Would you prefer the seed that gives you 2 kg paddy for sure or the second new seed that gives you either 2 kg or 18 kg paddy with an equal chance?

	Choice	Option 1	Option 2	Choice
Brown	2	50% **2** Kg of rice (Green) 50% **18** Kg of rice (blue)	**2** Kg of rice for sure	

If respondent has said 1 to Q1 and 2 to Q2, then re-explain using the same language as in the example. Do not lose your patience.
Keep in mind that you will not change their answers to these questions.

Now ask them to draw a chit from the bag to decide what they will finally get as reward.

If they draw a colour corresponding to which they have chosen option 1,

Now, you will have to take out a marble from this bag but you have to keep your eyes closed. If you take out the blue marble, you will get 18 pencils and if you take out the green one, you will get 2 pencils.

Time finished:____.

Appendix B: GoodsExperiment Protocol

Material required – Response sheet

(Please follow the standardized language very strictly)

In this activity, we want to understand how do you differentiate between these boxes of cookies and how do you choose one of them for yourself. (*point towards the biscuits)*

There are 3 types of biscuits here. (*show it to her one by one*) .
Now, I want you taste each of them one by one. This is very important because you have to make the choice out of these biscuits only. So, this will help you in making the choices. Do not hesitate.

Take the participant to the first decision.

Now I want you to choose a box out of these seven boxes. In each of these, biscuits are kept in different combinations and there are no right or wrong answers in this one. You should choose the one which you prefer most. But, remember one thing. At the end, I will ask you the reason for making these choices, so, think about your choices.

Now let her choose her preferred box at the first station.

Can you see this colour? (show her the colour attached with the first station).
There are eight colours like this and you have to choose a box that you prefer most.
I will keep on noting down your answers. (*show her the sheet*).*In the end, you will draw a chit and get a reward as well on the basis of the colour of the chit.*

(*Enumerator ,during the course of choosing, you should continue engaging with the respondents)*
Keep concentrating.

(*As you are moving around, keep pointing towards all the choices within the station for her with your hands)*
Have a look at all the boxes and then choose.

(Some respondents may feel shy about taking their preferred option for fear of appearing greedy. You have to detect that and tell them that this is not about greed)

This is not about greed, you have to understand that and then simply choose which you prefer most.

☺*Stay energetic*☺

	Cookie1	Cookie2	Cookie3
	Choice 1	Red	
1	1.5	0	0
2	0	3	0
3	0	0	12
4	0.5	1	4
5	0.75	0	6
6	0.75	1.5	0
7	0	1.5	6
	Choice 2	Cream	
1	1.5	0	0
2	0	4	0
3	0	0	6
4	0.5	1.33	2
5	0.75	0	3
6	0.75	2	0
7	0	2	3
	Choice 3	Brown	
1	1.33	0	0
2	0	4	0
3	0	0	12
4	0.44	1.33	4
5	0.66	0	6
6	0.66	2	0
7	0	2	6
	Choice 4	Blue	
1	0	1.5	0
2	0	0	3
3	12	0	0
4	4	0.5	1
5	6	0.75	0
6	0	0.75	1.5
7	6	0	1.5
	Choice 5	Light green	
1	0	1.5	0
2	0	0	4
3	6	0	0
4	2	0.5	1.33
5	3	0.75	0
6	0	0.75	2

	Cookie1	Cookie2	Cookie3
	Choice 6	Magenta	
1	0	1.33	0
2	0	0	4
3	12	0	0
4	4	0.44	1.33
5	6	0.66	0
6	0	0.66	2
7	6	0	2
	Choice 7	Occer	
1	0	0	1.5
2	3	0	0
3	0	12	0
4	1	4	0.5
5	0	6	0.75
6	1.5	0	0.75
7	1.5	6	0
	Choice 8	Orange	
1	0	0	1.5
2	4	0	0
3	0	6	0
4	1.33	2	0.5
5	0	3	0.75
6	2	0	0.75
7	2	3	0
	Choice 9	Dark Green	
1	0	0	1.33
2	4	0	0
3	0	12	0
4	1.33	4	0.44
5	0	6	0.66
6	2	0	0.66
7	2	6	0


7
3
0
2

Table 1: Survey Non-response

	Treatment		Control	
	(1)	(2)	(3)	(4)
Phase I				
TA assignment	135	100%	97	100%
TA participation	127	96%	4	4%
Phase II				
TA assignment	241	100%	191	100%
TA participation	153	63%	6	3%

Notes: Table 1 presents the randomization design. In Phase I, a total of 232 women were assigned to either treatment or control. In Phase II, a total of 432 women were assigned to either treatment or control. Not all women complied to their assigned status.

Table 2: Schedule of Choices of the Risk Experiment

	Lottery with		OR	Phase I	Schedule A	Schedule B
	50%	50%				
Choice 1	2	18		12	12	3
Choice 2	2	18		3	3	5
Choice 3	2	18		10	10	7
Choice 4	2	18		9	9	9
Choice 5	2	18		4	7	10
Choice 6	2	18		6	5	12
Choice 7	2	18		7	2	14
Choice 8	2	18		8	18	18
Choice 9	2	18		5		

Notes: Table 2 presents the sequence of choices the respondent was asked to make in the risk experiment. See the protocol in the appendix for more details.

Table 3: Descriptive Statistics on Covariates and Baseline Balance

	(1)	(2)	(3)	(4)
	All	Treatment	Control	Difference (s.e.)
Age (years)	33.99	33.63	34.46	-.83
	[9.95]	[10.23]	[9.58]	(.79)
Unmarried (1=yes ; 0 = no)	0.06	.07	.06	.01
	[.24]	[.25]	[.23]	(.02)
Widowed (1=yes;0=no)	0.04	.04	.04	0.00
	[.2]	[.20]	[.21]	(.02)
HH has Below Poverty (BPL) Card	0.29	.29	.30	-.01
	[.45]	[.45]	[.46]	(.04)
Number of Children	3.28	3.3	3.26	.04
	[1.97]	[2.09]	[1.82]	(.15)
Asset Index score	25.06	25.37	24.68	.69
(out of 100)	[12.9]	[12.88]	[12.94]	(1.01)
Baseline Forward Digit Span	5.23	5.27	5.17	0.10
(score out of 16)	[1.63]	[1.65]	[1.61]	(.13)
Baseline Rapid Automatic Naming	76.75	76.68	76.83	-.15
(in seconds)	[28.65]	[29.97]	[26.89]	(2.24)
Baseline Math Score	7.06	7.08	7.03	.05
(score out of 35)	[7.83]	[8.05]	[7.56]	(.61)
Baseline Letters per minute	1.72	1.87	1.54	.33
(in reading test)	[6.95]	[7.35]	[6.41]	(.54)
Observations	665	375	290	

Notes: Table 3 presents the mean and standard deviation (in brackets) of the covariates of the entire sample (Column 1), the treatment group (Column 2) and the control group (Column 3). BPL (Below Poverty Line) Ration Card issued to those people who have annual income of less than Rs 10,000. They are entitled to get food grains and fuel at lower prices from ration shops. The Asset Index Score is the Poverty Asset Index which combines information on assets and occupation of the household. The average PPI is 25. As a reference, a PPI of 20 corresponds to an about 90% chance of being under the poverty line using the international 2 USD/day/person poverty line.

Table 4: Descriptive Statistics on Outcomes

	(1)	(2)	(3)	(4)	(5)	(6)
	Whole Sample	Treatment	Control	Difference (s.e)	N treat	N control
Transitive Goods Choices	0.45	.44	.46	-.02	369	287
(1=transitive; 0=not transitive)	[.5]	[.50]	[.50]	(.04)		
Transitive Risk Choices	0.39	.41	.37	.05	357	273
(1=transitive; 0=not transitive)	[.49]	[.49]	[.48]	(.04)		
Rational with regards to Dominated Choices	0.68	.72	.62	.10**	241	193
(1=rational; 0 = not rational)	[.47]	[.45]	[.49]	(.05)		

Notes: Table 4 presents the mean and standard deviation (in brackets) of the outcome variables of the entire sample (Column 1), the treatment group (Column 2) and the control group (Column 3). Column 4 presents results a t-test of difference between the treatment and control group.

Table 5: Correlation of Rationality Measures (by Treatment Status)

	(1)	(2)
	Transitivity in Risk Choices	Opting for a dominated lottery
All observations		
Transitivity in Goods Choices	0.118***	0.0258
	[0.003]	[0.592]
Transitivity in Risk Choices		0.182***
		[0.000]
By treatment status		
Control Group		
Transitivity in Goods Choices	0.0653	-0.002
	[0.285]	[0.982]
Transitivity in Risk Choices		0.216***
		[0.003]
Treatment Group		
Transitivity in Goods Choices	0.1603***	0.061
	[0.003]	[0.355]
Transitivity in Risk Choices		0.156**
		[0.016]

Notes: Table 5 reports the correlation coefficient between the row outcome variable and the column outcome variable, as well as p-values in brackets. The first panel presentes correlations among all observations, the second panel presents correlations by treatment status. ***, **, * denote statistical significance at the 1, 5, 10 percent levels, respectively.

Table 6: Impact of Literacy and Numeracy Program on Transitivity in Goods Choices

	(1)	(2)	(3)	(4)
	simple means	incl. demographic variables	include cognitive covariates	IV
Treatment indicator variable	-0.020	-0.024	-0.025	
	(0.038)	(0.039)	(0.039)	
Participation indicator variable				-0.042
				(0.052)
Age (years)		0.000	-0.000	-0.000
		(0.002)	(0.002)	(0.002)
Unmarried (1=yes; 0=no)		-0.021	-0.016	-0.003
		(0.094)	(0.093)	(0.091)
Widowed (1=yes;0=no)		0.197**	0.201**	0.197**
		(0.092)	(0.093)	(0.091)
HH has Below Poverty (BPL) Card		0.016	0.024	0.024
		(0.045)	(0.046)	(0.045)
Number of Children		0.022*	0.019*	0.020*
		(0.011)	(0.011)	(0.011)
Asset Index Score		0.001	0.001	0.001
		(0.002)	(0.002)	(0.002)
Baseline Forward Digit Span			-0.001	-0.001
(score out of 16)			(0.001)	(0.001)
Baseline Rapid Automatic Naming			0.014	0.015
(in seconds)			(0.013)	(0.012)
Baseline Math Score			0.005	0.004
(score out of 35)			(0.003)	(0.003)
Baseline Letters per minute			-0.004	-0.004
			(0.003)	(0.003)
Strata fixed effects	Yes	Yes	Yes	Yes
Observations	656	632	627	625

Notes: Table 6 analyses the effect of the TA program on transitivity in the goods experiment. The dependent variable = 1 if the choices made are transitive and 0 if the choices made violate transitivity. Column (1) through (3) present the results of an OLS regression with robust standard errors. Column (4) present the results of an instrumental variable strategy with instrument: invited to the treatment and endogenous variable: participated fully or partially in TA. Set of covariates include stratificaction (sub-village) fixed effects. Huber-White robust standard errors presented in parentheses. ***, **, * denote statistical significance at the 1, 5, 10 percent levels, respectively.

Table 7: Impact of Literacy and Numeracy Program on Transitivity in Risk Choices

	(1)	(2)	(3)	(4)
	simple means	incl. demographic variables	include cognitive covariates	IV
Treatment indicator variable	0.039	0.040	0.044	
	(0.036)	(0.038)	(0.038)	
Participation indicator variable				0.055
				(0.052)
Schedule A indicator variable	-0.056	-0.065	-0.035	-0.032
	(0.129)	(0.137)	(0.141)	(0.157)
Schedule B indicator variable	0.246	0.239	0.276	0.259*
	(0.166)	(0.171)	(0.171)	(0.154)
Age (years)		-0.002	-0.001	-0.001
		(0.002)	(0.002)	(0.002)
Unmarried (1=yes; 0=no)		-0.084	-0.096	-0.095
		(0.067)	(0.065)	(0.086)
Widowed (1=yes;0=no)		0.020	0.019	0.013
		(0.092)	(0.091)	(0.091)
HH has Below Poverty (BPL) Card		-0.051	-0.045	-0.052
		(0.037)	(0.037)	(0.042)
Number of Children		0.010	0.011	0.010
		(0.011)	(0.011)	(0.011)
Asset Index Score		0.001	0.001	0.001
		(0.002)	(0.002)	(0.002)
Baseline Forward Digit Span			-0.001	-0.001
(score out of 16)			(0.001)	(0.001)
Baseline Rapid Automatic Naming			-0.012	-0.010
(in seconds)			(0.013)	(0.013)
Baseline Math Score			-0.001	-0.001
(score out of 35)			(0.003)	(0.003)
Baseline Letters per minute			0.001	0.001
			(0.003)	(0.003)
Strata fixed effects	Yes	Yes	Yes	Yes
Observations	630	611	608	606

Notes: Table 7 analyses the effect of the TA program on transitivity in the risk experiment. The dependent variable = 1 if the choices made are transitive and 0 if the choices made violate transitivity. Column (1) through (3) present the results of an OLS regression with robust standard errors. Column (4) present the results of an instrumental variable strategy with instrument: invited to the treatment and endogenous variable: participated fully or partially in TA. Set of covariates include stratificaction (sub-village) fixed effects. Huber-White robust standard errors presented in parentheses. ***, **, * denote statistical significance at the 1, 5, 10 percent levels, respectively. See also Notes to Table 6.

Table 8: Impact on Rationality with regards to Dominated Choices

	(1)	(2)	(3)	(4)
	simple means	incl. demographic variables	include cognitive covariates	IV
Treatment indicator variable	0.062**	0.057**	0.058**	
	(0.029)	(0.026)	(0.026)	
Participation indicator variable				0.119**
				(0.059)
Schedule A indicator variable	-0.454***	-0.433***	-0.437***	-0.344***
	(0.046)	(0.049)	(0.049)	(0.029)
Age (years)		-0.002	-0.001	-0.002
		(0.002)	(0.002)	(0.002)
Unmarried (1=yes; 0=no)		-0.028	-0.046	-0.060
		(0.081)	(0.087)	(0.091)
Widowed (1=yes;0=no)		0.027	0.027	0.027
		(0.064)	(0.064)	(0.084)
HH has Below Poverty (BPL) Card		-0.067	-0.066	-0.075*
		(0.044)	(0.044)	(0.042)
Number of Children		0.002	0.002	0.000
		(0.010)	(0.010)	(0.010)
Asset Index Score		-0.000	-0.000	-0.001
		(0.002)	(0.002)	(0.002)
Baseline Forward Digit Span (score out of 16)			0.000	0.000
			(0.001)	(0.001)
Baseline Rapid Automatic Naming (in seconds)			-0.001	0.003
			(0.014)	(0.013)
Baseline Math Score (score out of 35)			0.001	0.001
			(0.003)	(0.003)
Baseline Letters per minute			0.003	0.002
			(0.003)	(0.003)
Strata fixed effects	Yes	Yes	Yes	Yes
Observations	434	431	430	428

Notes: Table 8 analyses the effect of the TA program on dominated choices chosen in the risk experiment. The dependent variable = 1 if no dominated choice is chosen and 0 if a dominated choice is chosen. Column (1) through (3) present the results of an OLS regression with robust standard errors. Column (4) present the results of an instrumental variable strategy with instrument: invited to the treatment and endogenous variable: participated fully or partially in TA. Set of covariates include stratificaction (sub-village) fixed effects. Huber-White robust standard errors presented in parentheses. ***, **, * denote statistical significance at the 1, 5, 10 percent levels, respectively. See also Notes to Table 6.

Table A1: Impact of Tara Akshar on Literacy and Numeracy Outcomes (IV estimates)

	(1)	(2)	(3)	(4)
	Letters per minute	Grade 1 words per minute	Single and double digit recognition	Mathscore (out of 35)
TA Participation	5.688***	3.098**	4.122***	8.456***
	(1.226)	(1.285)	(0.407)	(0.935)
Observations	596	596	596	596
R-squared	0.237	0.170	0.323	0.356

Notes: Regression results from Deshpande et al (2015). Table 1A reports on the effects of TA on various reading and mathematics scores using an instrumental variable strategy with instrument: invited to the treatment and endogenous variable: participated fully or partially in TA. Regression include sub-village fixed effects to account for stratification. Huber-White robust standard errors presented in parentheses. ***, **, * denote statistical significance at the 1, 5, 10 percent levels, respectively. column (1) indicates the number of Hindi letters correctly read in 1 minute, column (2) indicates the number one- or two-syllable words read correctly in 1 minute, column (3) indicate score indicates the number of single digit and double digit correctly named, Column (4) is total maths score comprising of oral counting,digit identification, counting number of items, subtraction and addition problems.

Table A2: Impact on Proportion of Rational Decisions with respect to Dominated Choices

	(1)	(2)	(3)	(4)
	simple means	incl. demographic variables	include cognitive covariates	IV
Treatment indicator variable	0.063**	0.065**	0.067**	
	(0.032)	(0.032)	(0.032)	
Participation indicator variable				0.101**
				(0.050)
Schedule A indicator variable	-0.161***	-0.151***	-0.153***	-0.147***
	-0.03	-0.031	-0.031	-0.03
Age (years)		-0.002	-0.001	-0.001
		(0.002)	(0.002)	(0.002)
Unmarried (1=yes; 0=no)		-0.046	-0.061	-0.072
		-0.067	-0.069	-0.069
Widowed (1=yes;0=no)		0.014	0.011	0.006
		(0.064)	(0.064)	(0.062)
HH has Below Poverty (BPL) Card		-0.051	-0.050	-0.054
		(0.036)	(0.037)	(0.036)
Number of Children		0.000	0.001	-0.001
		(0.007)	(0.007)	(0.007)
Asset Index Score		-0.001	-0.001	-0.001
		(0.001)	(0.001)	(0.001)
Baseline Forward Digit Span			-0.000	0.000
(score out of 16)			(0.001)	(0.001)
Baseline Rapid Automatic Naming			-0.005	-0.002
(in seconds)			(0.012)	(0.011)
Baseline Math Score			0.000	0.001
(score out of 35)			(0.002)	(0.002)
Baseline Letters per minute			0.003	0.002
			(0.002)	(0.002)
Strata fixed effects	Yes	Yes	Yes	Yes
Observations	434	431	430	428

Notes: Table A2 analyses the effect of the TA program on dominated choices chosen in the risk experiment. The dependent variable is the proportion of rational choices made by the woman, which depends on the number of choice sets with dominated choices that she faces.. Column (1) through (3) present the results of an OLS regression with robust standard errors. Column (4) present the results of an instrumental variable strategy with instrument: invited to the treatment and endogenous variable: participated fully or partially in TA. Huber-White robust standard errors presented in parentheses. ***, **, * denote statistical significance at the 1, 5, 10 percent levels, respectively. See also Notes to Table 6.