AGRIALLIS
Science for Agriculture and Allied Sector: A Monthly Magazine
Volume 5, Issue 8
www.agriallis.com

Article Id
AL04251

RANDOMIZED CONTROL TRIALS (RCTs): AN ANALYTICAL TECHNIQUE TO ASSESS THE IMPACT OF AGRICULTURAL TECHNOLOGIES AND POLICIES

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Three-quarters of the world's poor live in rural areas, and many rely on agriculture directly or indirectly. Agricultural technology has the ability to improve their lives by increasing yields, decreasing risk, and improving nutrition. However, adoption of these innovations, ranging from better seeds to financial products such as microinsurance, remains minimal. Extensive research is being conducted to encourage adoption, increase farmer income, manage the risks inherent in agriculture, and better connect farmers to markets. Impacts are defined by the OEDC-DAC as "positive and negative, primary and secondary long-term effects produced by a development intervention, directly or indirectly, intended or unintended. An impact evaluation can be conducted formative (improving or reorienting a program or policy) or summative (informing decisions about whether to continue, cease, replicate, or scale up a program or policy). RCTs were shown to be more trustworthy than other impact evaluation methods. Randomization is now an essential instrument in the repertoire of a development economist. Application of RCTs includes various fields such as Agriculture, Crime, violence & conflict, Education, Environment, energy & climate change, Finance, Firms, Gender, Health, Labour market and Political economy & governance etc.

Impact Evaluation Methods

1. Randomized Controlled Trials (RCTs) Also known as: – Random Assignment Studies, Randomized Field Trials, Social Experiments, Randomized Trials, Randomized Experiments, Randomized Controlled Experiments

2. Non or Quasi-Experimental Methods: these methods rely on being able to mimic the counterfactual under certain assumptions which at present are not testable

- Pre-Post

- Simple Difference
- Differences-in-Differences
- Multivariate Regression
- Statistical Matching
- Interrupted Time Series
- Instrumental Variables
- Regression Discontinuity

Randomized Controlled Trials (RCTs)

A randomized controlled trial (RCT) is a method of evaluating the impact of a program or policy intervention in which the population receiving the intervention is chosen at random from the eligible population, and a control group is likewise chosen at random from the same eligible population. It assesses the extent to which specific, planned effects are realized. RCTs can be used to assess both program interventions (for example, nutritional supplements delivered as part of a nutrition program) and policy interventions (for example, cash distributed as part of a cash transfer policy). RCTs are most suited for programs that aim to achieve clear, measurable outcomes that can be linked to a specific intervention or group of interventions and lend themselves to causal pathway analysis. RCTs are not well suited to programs that are emergent, or which seek to achieve results that are hard to measure.

Key Steps in Conducting a Randomized Evaluation: (White, 2013)

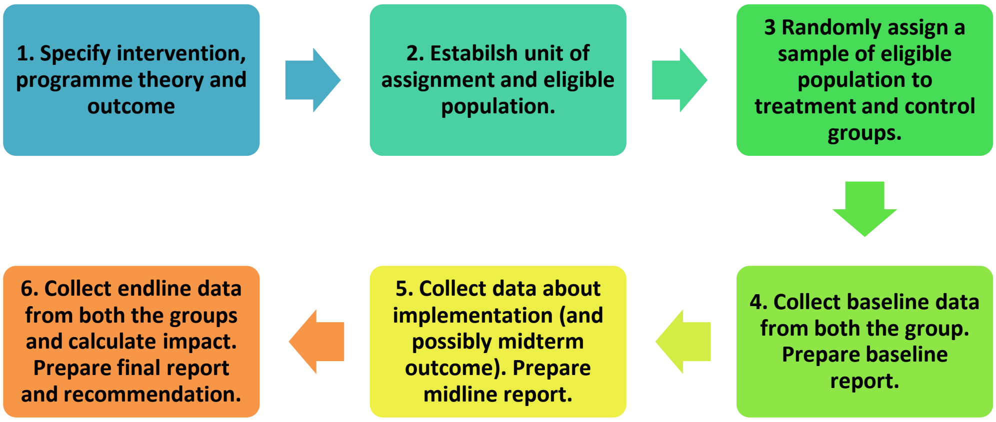

Fig. 1: Overview of conducting an RCT

Example: Mobile Phone-Based Extension Services and Agricultural Advice for Cotton Farmers in Gujarat, India conducted by **Cole and Fernando, J-PAL**.

- After China, India is the world's second-largest cotton grower. Despite this, Indian cotton productivity ranks 78th in the world, with yields just one-third of those of China. While financing limits, a lack of insurance markets, and poor infrastructure may explain some of this gap, a number of commentators have suggested that access to knowledge and awareness of agricultural technologies may also play a role (Jack, 2011). For decades, the Government of India, like most governments in developing countries, has run an agricultural extension system designed to disseminate information about new agricultural practices and technologies through a vast workforce of public extension agents. However, there is little evidence that these extension services are effective. In India, dispersed rural populations, monitoring challenges, and a lack of accountability limit the effectiveness of in-person extension systems: less than 6% of the agricultural population reports receiving information from these programs.

- In the absence of expert advice, farmers rely on word of mouth, generic broadcast programming, or agricultural input suppliers, who may be ignorant or have incentives to recommend the wrong product or overdose (Anderson and Birner, 2007). The development of mobile phone networks, as well as the rapid expansion of mobile phone ownership in South Asia and Sub-Saharan Africa, has given rise to the possibility of offering agricultural extension services in a fundamentally new way.

- This study examines whether the introduction of an information service that is able to deliver timely, relevant, and actionable information to farmers can meaningfully influence agricultural practices. Specifically, they evaluate Avaaj Otalo (AO), a mobile phone-based technology service that both pushes information to farmers via voice calls, and allows users to call a hotline, ask questions, and receive a recorded response from agricultural scientists and local extension workers. Callers can also listen to answers to questions posed by other farmers.

Particulars in case of mobile based extension service in Gujarat, India	
Intervention type	• Digital and mobile; Extension services; Information; Nudges and reminders; Training
Outcome of interest	• Technology adoption
Unit of assignment	• Farmers
Eligible population	• 1200 farmers across 40 villages having mobile phones

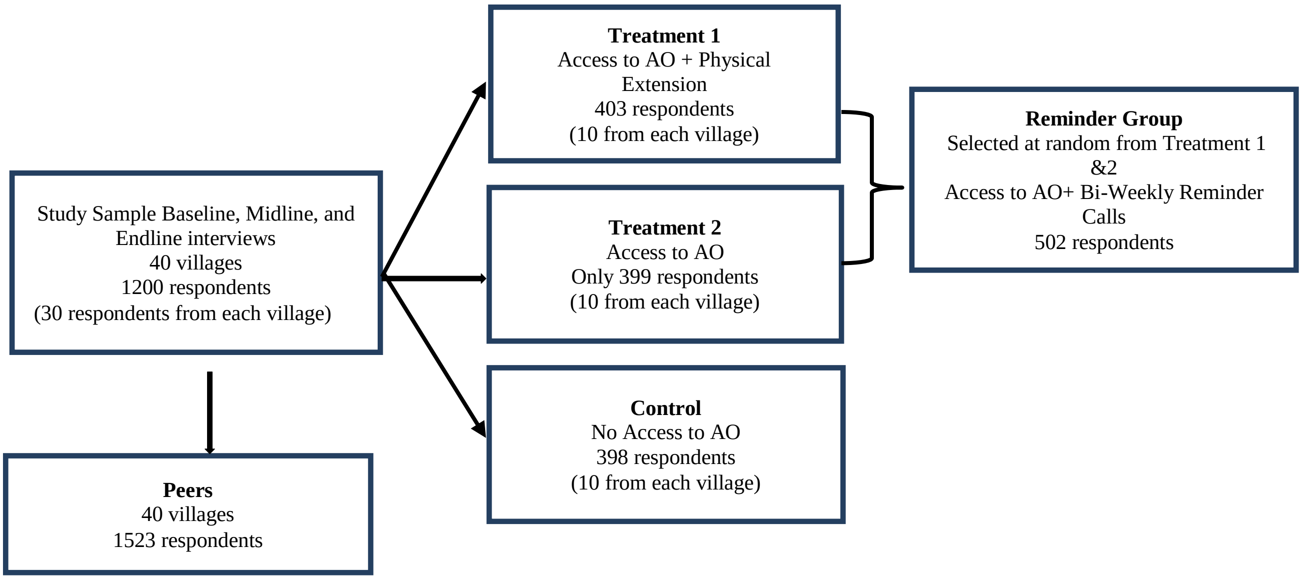

Fig. 2: Experimental design

Why Randomize?

There are many ways to estimate a programme's impact but i argued in favour of randomized experiments due to:

1. Conceptual Argument: -If properly designed and conducted, RCTs provide the most credible method to estimate the impact of a program

- Because the members of the treatment and control groups do not differ consistently at the start of the evaluation.
- Baseline data in the preceding example show that randomization was largely successful for the treatment groups across demographic characteristics (respondents are on average 46 years old and have approximately four years of education) and indices capturing information sources, crop-specific and general input use. At the baseline, there are no imbalances between treatment and control.
- Any difference that subsequently arises between them can be attributed to the program rather than to other factors.

Take-Up and Usage of AO

Cole and Fernando reported that nearly 90% of treatment respondents had called into the service by the end line (after two years), and the mean total usage for the combined treatment group (AO & AOE) - including both incoming calls and time spent listening to push calls - was 7 hours (median 5.2 hours). By the end, 40% of treated responders had asked the system a question about their agriculture.

Agricultural Input Adoption

The therapy enhanced the cotton and seed management indexes by 0.12 and 0.09 standard deviations, respectively. They find no evidence of increased fertilizer adoption across all crops. Total input expenditure increased by about 8% relative to the baseline control mean across specifications, with irrigation and seeds spending increasing by roughly 15% and 20%, respectively, relative to the baseline control mean.

2. Empirical Argument: -Different methods can generate different impact estimates

Unit of Randomization:

- The RCT approach is adaptable enough to fit a wide range of situations and industries. The unit of analysis for the intervention and the random assignment is the same in a simple RCT. However, for practical and ethical reasons, a cluster RCT design, in which the unit of assignment incorporates multiple treatment units, is more commonly used.
- Randomizing at the individual level
- Randomizing at the group level "Cluster Randomized Trial"

Methods of Randomization

There are various approaches to implementing an RCT for a programme, such as phase in (pipeline), encouragement design, within-group randomization, oversubscription, and so on, but the RCT design should be chosen based on the programme characteristics (White et al., 2014).

Random Assignment

- There are various methods for randomly assigning population groups to treatment and control groups, including basic randomization, matched pair randomization, stratified random assignment, and so on.

• **Simple randomization**-It is listing individuals or sites and then assigning them to treatment and control groups using random numbers generated, for example, by a random number generator.

- **Matched pair randomization** – Individuals or clusters are divided into pairs based on observed similarities. Each pair has one unit assigned to the treatment group and the other to the control group at random. This first matching ensures balance and decreases the sample size required.
- **Stratified random assignment** – Participants are sorted into groups (strata) based on crucial variables that are likely to influence outcomes, such as income or education, and then randomization is performed for each group. This guarantees that essential variables are distributed equally throughout the treatment and control groups.

Statistical Power and Sample Size

An RCT may only be utilized when the sample size is large enough to detect program effects with adequate precision; the study design must have sufficient 'power'. The power of the design is the likelihood that we will be able to reject the hypothesis of no impact for a given effect size and statistical significance level (Duflo et al., 2006). According to the convention, 80% is a sufficient level of power.

Power: Main Ingredients

• **Effect Size**: A large effect may be distinguished from zero more easily than a tiny effect.
• **Variability**: Lower variability in the outcome variable makes distinguishing an effect easier.
• **Sample Size**: A higher sample size means that the treatment and control groups are more representative of the broader population, making it simpler to detect an effect.
• **Sample Split:**Equal proportions of treatment and control make it easier to discern an effect.

Minimal Detectable Effect Size

The smallest effect size that can be identified with a particular statistical power (e.g., 80% chance of accurate positive), statistical significance (e.g., 5% probability of false positive), and sample. We can alter the sample size based on the MDE to achieve a realistic experimental design. Bloom (1995) developed a formula to calculate MDE.

$$\mathbf{MDE_{\beta} = (t_{k} + t_{\alpha}).\sqrt{\frac{1}{P(1-P)}\frac{\sigma^{2}}{N}}}$$

Where,

MDE_{β} = Minimal detectable effect,

$(t_{k} + t_{\alpha})$ = Critical values from Student t for power κ and significance level α

σ^2 = Variance

P = Proportion in Treatment

N = Sample size

The MDE will be smaller with llarger sample size N, smaller outcome variance $\sigma^2$and even proportion in treatment (P = 0.5).

Power in Clustered Designs

A number of factors influence statistical power, including sample size, the minimum detectable effect size (i.e. how sensitive the test must be), the underlying variance of the outcome variable, the proportion of participants in treatment and control, and, if the study is a cluster RCT, intracluster/intraclass correlation. When the number of clusters in a cluster RCT is raised, statistical power increases more than when the number of individuals or groups inside a cluster is increased.

Intraclass correlation (ICC): Intraclass correlation defines how similar - how correlated - units are within the same class or cluster. Kendall (2003) defines the ICC as the fraction of total variance accounted for by between-class variation.

Total variance(σ^2) can be divided into within-class variance (σ_n^2), and between-class variance (σ_v^2)

- **High ICC (close to 1):** subjects in the same cluster are similar; different clusters tend to be very different from each other.
- **Low ICC (close to 0):** Subjects in the same cluster are not particularly similar; other clusters are more similar to one another and more closely reflect the population as a whole.

The higher the intraclass correlation, the higher the required sample size.

MDE in case of clustered design is calculated as (Bloom, 1995):

$$\mathbf{MDE_{\beta} = (t_k + t_{\alpha}).\ \sqrt{\frac{1}{P(1-P)}\frac{\sigma^2}{N}}\ .\ \sqrt{1+(m-1).\ ICC}}$$

Where,

m = cluster size

ICC = Intraclass correlation

The MDE will be smaller with larger sample size N, smaller outcome variance (σ^2),even proportion in treatment (P = 0.5) and lower ICC.

Power calculations step by step:

• Decide on your target power (e.g., 80%) and significance level (e.g., 5%).

• Determine the allocation ratio (sample split), for example, based on the cost of data collection (control and treatment) and intervention (just treatment).

• Inquire about the predicted treatment impact. Which effect sizes do we want to be able to detect? - This is used to configure the MDE.

• Calculate the variance and ICC.

• Calculate the sample size and project the study costs.

Threats Involved in Conducting RCTs

Even if random assignment is put in place, there are several potential challenges. These are:

- ✓ low take-up of the intervention;
- ✓ lack of compliance with intended procedures
- ✓ Contamination of the control group by other interventions affecting similar outcomes or through self-contamination; and
- ✓ Change in the design or location of the programme being evaluated, which are discussed under the following points.
- ✓ Partial Compliance and Sample Selection Bias: Intention to Treat & Local Average Treatment Effect
- ✓ Attrition
- ✓ Unexpected Spillovers
- ✓ Behavioral Responses to Evaluations
- ✓ Research Transparency

Generalizations of RCT Results

- Our focus has largely been on issues of internal validity up to this point, or whether we can infer that the intervention in the sample actually had the impact that was measured.
- Although crucial, internal validity is insufficient for external validity.
- The applicability of the influence we quantify to various populations or samples is known as external validity. Or, whether the results are replicable and transportable.

Application of RCTs to Indian Agriculture

- Mobile Phone-Based Extension Services and Agricultural Advice for Cotton Farmers in Gujarat, India by Shawn Cole and A. Nilesh Fernando
- Formal Rainfall Insurance for the Informally Insured in India by MushfiqMobarake and Mark Rosenzweig
- Diffusing new seeds through social networks in Indian village economies by Kyle Emrick
- Irrigation Tank Rehabilitation for Improved Agricultural Outcomes and Water Management in India by Aprajit Mahajan, Xavier Gine, Anup Malani and Manaswini Rao
- Group Incentives, Hygiene, and Milk Quality Among Dairy Cooperatives in Karnataka, India by J-PAL South Asia
- Targeted Information for The Adoption of Flood-Tolerant Rice in India by Manzoor Dar, Kyle Emerick and Elisabeth Sadoulett
- Marketing Rainfall Insurance in India by Shawn Cole, Sarthak Gaurav and Jeremy Tobacman
- The Impact of Drought-Tolerant Rice on Local Labor Markets in India by Alain de Janvry, Elisabeth Sadoulet, Kyle Emerick and Manzoor H. Dar
- Demand for Rainfall Insurance in India by Shawn Cole, Daniel Stein, Xavier Gine, Jeremy Tobacman, Petia Topalova, Robert Townsend and James Vickery

Conclusion

Since internal validity is an RCT's greatest strength, anything that could undermine it must be carefully taken into account. The capacity to overcome obstacles during the implementation phase is just as crucial as the design phase and power calculations. Making a clear distinction between incomplete compliance, spillovers, and attrition and considering the effects of experiments is also crucial in RCTs and randomized evaluation can be done when there is time, expertise, and money to accomplish it well ,not too early or too late in the implantation stages of intervention. Programme is representational but not gold-plated - Or tests a fundamental notion we need to test By Creating a plan for prioritising evaluations and Seize opportunities as they arise RCTs can be conducted. Randomized evaluation cannot be conducted-when the project is too small to randomly divide into two "representative groups", the programme is premature and still needs significant "tinkering" to function well and when the programme is premature and still needs considerable "tinkering" to function well.

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