Lecture 9

Quasi Experiments- Before-After-Control-Impact Designs

Simple Analysis Method Description

Nathan Tarr - Example of Disturbance Experiments on Shorebirds

Guest Lectures Coming Up

Jim Gilliam will come on Thursday February 21, 2008.

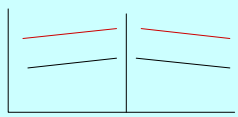
Ted Simons will come on Thursday February 28, 2008

Homework 3 Due February 19, 2008

1. Complete the generalized paired T test and the Signed Rank test for the artificial BACI data set sent to you in the spreadsheet.
2. Either find an example of use of a replicated or unreplicated BACI design in the literature or suggest one that might be of interest for you to carry out if you had time. (very brief answer –say half page)

Before- After- Control-Impact Designs

Conceptual Figure-No Impact , Idealised True Mean Pattern

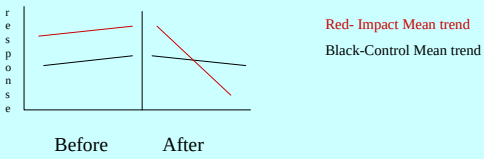


Red- Impact Mean trend
Black-Control Mean trend

Before After

Before- After- Control-Impact Designs

Conceptual Figure on True Mean Pattern- Negative Impact Seen

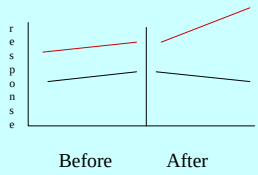


Red- Impact Mean trend

Black-Control Mean trend

Before- After- Control-Impact Designs

Conceptual Figure on True Mean Pattern- Positive Impact Seen

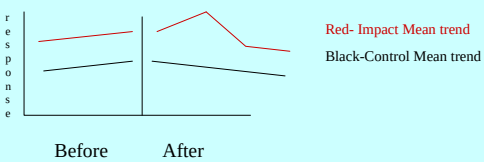


Red- Impact Mean trend

Black-Control Mean trend

Before- After- Control-Impact Designs

Conceptual Figure on True Mean Pattern- Positive then Negative Impact Seen and then Parallel again. Many other patterns over time are possible.



Red- Impact Mean trend

Black-Control Mean trend

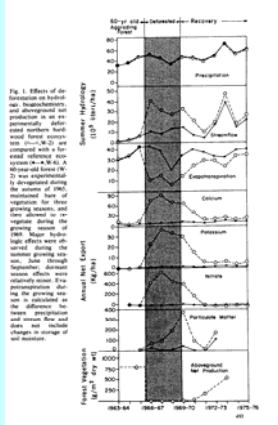
Before- After- Control-Impact Designs: Key Assumption Repeated

The control and treatment plots have the same trajectories aside from an additive effect due to the impact or treatment

This means we then can adjust out the inherent site differences between treated and controls.

BACI DESIGN EXAMPLE: HUBBARD BROOK RECOVERY OF A FORESTED SYSTEM AFTER DEFORESTATION

- One Control (Reference) Watershed
- One Clearcut Watershed
- No replication but the responses are so large that the results are convincing
- Measured responses over Time (Before and After 1965-68). Many variables measured like stream flow, evapotranspiration and net export of Ca,K, and Nitrate
- Classic pattern of large increases in many variables on clearcut compared to control site which then returned to baseline levels in a few years.



Note

Huge Impacts Shown On

Many Variables

BACI DESIGN EXAMPLE: HUBBARD BROOK RECOVERY OF A FORESTED SYSTEM AFTER DEFORESTATION: DISCUSSION

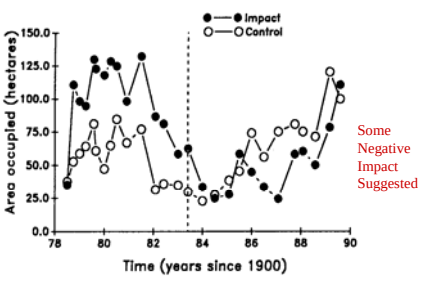
Discussion

- Very widely cited and important study despite lack of replication.
- Spatial Scale was watershed (reasonably large and therefore of great interest).
- Responses were very large (who needs testing here?)
- Very Good Control Site is important to the validity of the study

BACI Designs: Nuclear Power Plant Example

- One Control Site and One Impacted Site over Time (Before and After 1983 when nuclear plant went online).
- Control-San Mateo Kelp Forest
- Impact- San Onofre Kelp Forest-Reduced light levels on the Ocean Floor from the cooling system
- Measure-Area Occupied by the Kelp Forest

Note- In this case again without true replication but still useful to illustrate the concepts



Some Negative Impact Suggested

Figure 8.1. Data on areas occupied by densities of giant kelp plants exceeding approximately 0.04 m^{-2}, as determined by side-scan SONAR for the Impact (San Onofre kelp forest) and Control (San Mateo kelp forest) sites over time. Data were collected by Ecosystem Management Associates for 300 survey areas at each site (see Murdoch et al. 1989). Dashed vertical line separates Before and After periods.

BACI DESIGNS ANALYSIS METHODS

Types of Analyses

No Replicates

Time Plots, Possibly (rarely) time series

Replicates

One time point- T Tests (Rank Tests).

Multiple time points- Repeated Measures ANOVA.

BACI DESIGNS: ANALYSIS FOR ONE TIME POINT

Replicates are Possible

One time point or a summary measure over time (the mean).

Standard Designs

Unpaired Sites -Two sample T test or Two Sample Rank test

Paired Sites- Paired T test or Signed Rank test

Note -Sometimes only replicate control sites, Sometimes pairing of sites although desirable is not possible.

Aside-Remember the Paired T Test

- We will extend the ideas of this test to the BACI design

Paired T Test

Paired Plots Two Treats A and B

Equivalent to a Randomised Complete Block Design

Paired T Test (Assumes Normality)

$D_i = (X_{Ai} - X_{Bi}) \quad i = 1,\ldots,n$

$H_0 \quad \mu_D = \mu_A - \mu_B = 0$

$H_1 \quad \mu_D = \mu_A - \mu_B \neq 0$

$$T = \frac{\overline{D}}{\sqrt{\frac{s_D^2}{n}}} \quad \text{df} = (n-1)$$

Calculate p values etc

Consider the Structure of the data

- We will use the paired control and impacted plot design where before and after data is collected
- We will look at how the difference between the impact plot after-before vs the control plots after-before
- By combining these we can eliminate any time effect just leaving the impact effect.

Paired Control and Impact Plots ($i = 1,2,\ldots,n$)

Control Plot Component

$(X_{CAi} - X_{CBi})$ is difference for control site i after - before

Measures Time Effect or Change Only

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Paired Control and Impact Plots ($i = 1,2,\ldots,n$)

Impacted Plot Component

$(X_{IAi} - X_{IBi})$ is difference for impacted site i after – before.

Measures (Impact Effect + Time Effect)

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Paired Control and Impact Plots (i = 1,2,..., n)

Both Components Shown

$(X_{IAi} - X_{IBi})$ is difference for impacted site i after – before.

Measures (Impact Effect + Time Effect)

$(X_{CAi} - X_{CBi})$ is difference for control site i after - before

Measures Time Effect Only

Paired Control and Impact Plots (i = 1,2,..., n)

$(X_{IAi} - X_{IBi})$ is difference for impacted site i after – before.

Measures (Impact Effect + Time Effect)

$(X_{CAi} - X_{CBi})$ is difference for control site i after - before

Measures Time Effect Only

$D_i = (X_{IAi} - X_{IBi}) - (X_{CAi} - X_{CBi})$

is an estimate of the Impact Effect on Site i. The Time Effect has been eliminated -

Crucial Assumption : Parallel Response for Control and Impact Sites except for impact effect.

BACI DESIGNS: SIMPLE ANALYSIS METHOD WITH ONE MEASURE AND NORMALITY ASSUMED

Paired Control Impact Plots

$D_i = (X_{IAi} - X_{IBi}) - (X_{CAi} - X_{CBi})$

$i = 1,..., n$ (paired sites)

$H_0 \mu_D = 0$ No Impact

$H_1 \mu_D \neq 0$ Impact

Cary out paired t test

Statistic $T = \dfrac{\bar{D}}{\sqrt{\dfrac{s_D^2}{n}}}$, df $= (n-1)$

Calculate p value etc

BACI DESIGNS: SIMPLE ANALYSIS METHOD WITH ONE MEASURE.

Artificial Example Paired T Test Extension, Signed Rank Test

Stream Liming Example Artificial Data-Response PH									
Pair	Control				Impact				Overall
No	Before	After	Difference		Bebore	After	Difference		Difference
1	6.2	6.4	0.2		6.1	7.5	1.4		1.2
2	6.1	6.4			6.2	7			
3	5.8	5.9			6	7.9			
4	5.8	6.3			6	7			
5	6.6	6.6			6.7	7.9			
6	6.9	6.8			7.1	6.9			
7	6.7	6.7			6.4	7.5			
		Calculate Generalised Paired T Test and find its p value.							
		Calculate Signed Rank Test and Reject Ho or Not							
		Rank all the differences ignoring sign. Sum all the plus Ranks.							
		Information -The critical value of T+ the sum of all the plus ranks is 26 or greater for 0.05							

First Pair

$D_1 = (X_{IA1} - X_{IB1}) - (X_{CA1} - X_{CB1})$

$D_1 = (7.5 - 6.1) - (6.4 - 6.2)$

$D_1 = (+1.4) - (+0.2)$

$D_1 = 1.2$

See SpreadSheet

Compute all Differences and then carry out the test.

BACI DESIGNS: SIMPLE ANALYSIS METHOD WITH ONE MEASURE AND NON NORMALITY ASSUMED

Paired Control Impact Plots

$D_i = (X_{IAi} - X_{IBi}) - (X_{CAi} - X_{CBi})$

$i = 1,\ldots,n$ (paired sites)

$H_0 \mu_D = 0$ No Impact

$H_1 \mu_D \neq 0$ Impact

Compute Signed-Rank Statistic

Rank the differences ignoring the signs

Count up the ranks of the differences that are $+$.

Find p value of test.

Nathan Tarr MS Student in Zoology (Ted Simons) Shorebird Disturbance Study

- Uses Simple Replicated BACI Design Ideas like those I described earlier.
- Really interesting and important study.