Industrial Case Studies

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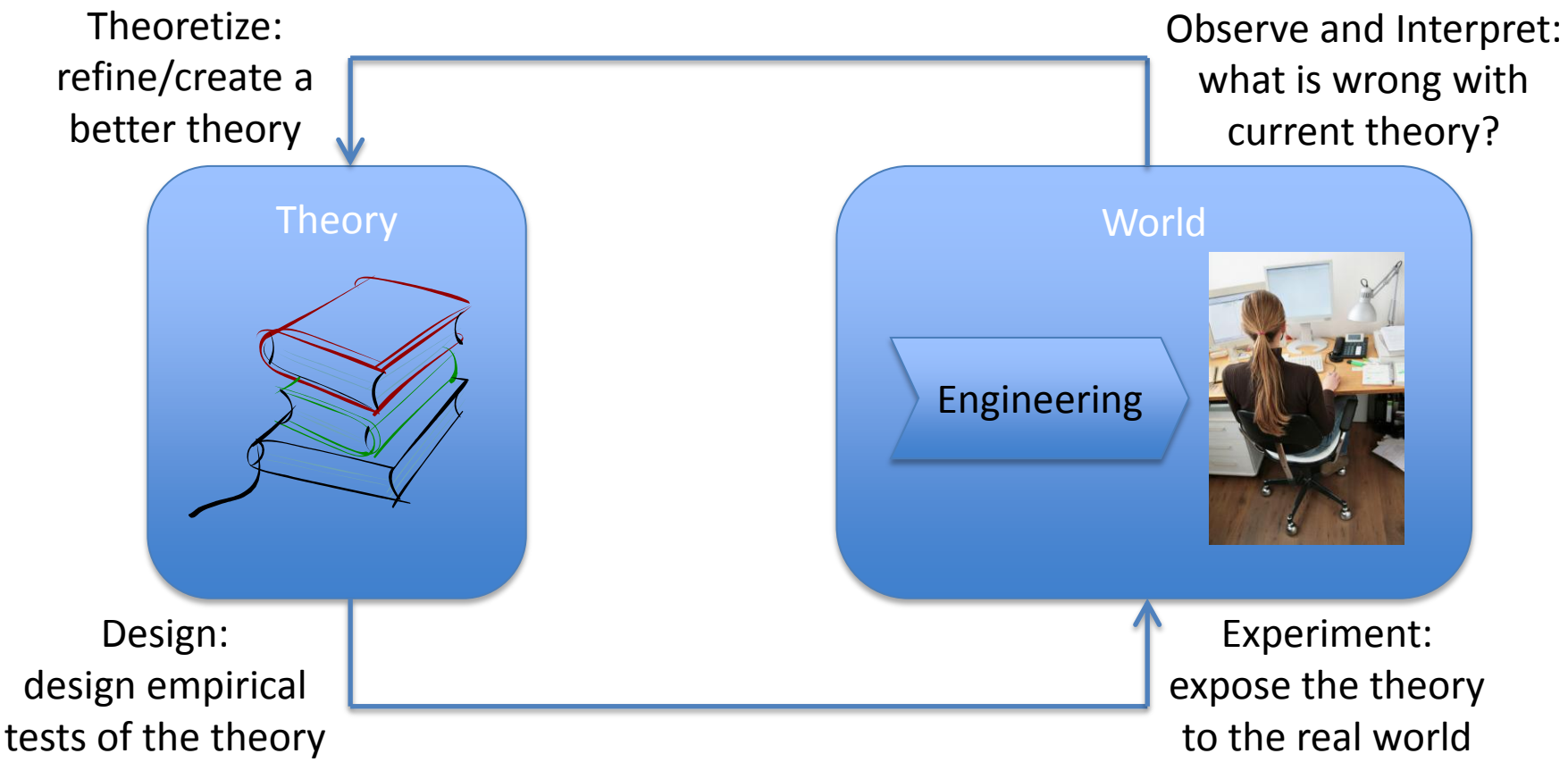
BLEKINGE INSTITUTE OF TECHNOLOGY

Empirical Research



Leading Question

- How are we going to evaluate a theory, if we have only few real-world instances of the phenomenon of interest available?
  - One instance
  - Up to a dozen instances

Inquiry Method Selection

	Survey	Case Study	Experiment
Research question	Who, What, Where, How many, How much	How, Why	How, Why
Kind of knowledge	Existence, Frequency, Distribution	Existence, Description	Causality, Comparative
Number of data points required	Many	1+	Many
Number of variables studied	Few	Many	1+
Phylosophical stance	Positivist: truth identification	Constructivist: local theory generation	Positivist: theory verification
Control of events required	No (real world)	No (real world)	Yes (laboratory)
Generalization	Statistically	By theory	Statistically

Inquiry Method Selection

Example

	Survey	Case Study	Experiment
Research question	How often do misunderstandings happen?	How can misunderstanding be avoided?	How can misunderstanding be avoided?
Kind of knowledge	Probability of misunderstandings in different contexts.	List and classification of techniques and their purposes	Comparison of two techniques to identify the better one.
Number of data points required	»100 distributed over the whole population	1 organization (2 practitioners)	»10 to achieve statistical reliability
Number of variables studied	Procurement context, % of cases with misunderstandings	Practitioner judgment and practice related to 18 requirements and design qualities	2 techniques, % of cases with misunderstandings
Phylosophical stance	xy% procurements suffer from misunderstandings	Successful, trusting practitioners do…	Technique A leads to less misunderstandings than technique B
Control of events required	Good population coverage. No influence on practitioners.	Critical case selection. No influence on ractitioners.	Typical practitioners selection. Control of proper technique application and of confounding factors.
Generalization	High/low confidence	Control theory, supported not perfect specification	High/low confidence

Contents

Understand

- Case studies as a research method
  - Motivation
  - Key Ideas
  - Key Techniques

Be able to

- Differentiate case studies from
  - Other empirical research methods
  - Data collection

Agenda

- Primer in Case Study Research
- Designing and Preparing a Case Study
- Collecting and Analyzing Evidence
- Conclusions

Case Study Defined

- The case study is an empirical inquiry that
  - investigates a contemporary phenomenon in depth and within its real-life context

Experiment isolates the phenomenon from real-life

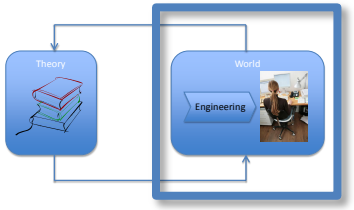
Surveys are limited to investigate context

History looks at past

- The case study inquiry
  - Many more variables of interest than data points
  - Multiple sources of evidence, with data needing to converge in a triangulating fashion
  - Needs theory to guide data collection and analysis

Yin (2009): Case Study Research: Design and Methods. Sage.

Requirements Understanding



Example

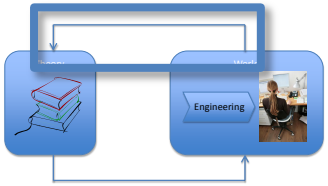
- Customer (Product Manager):
  - How do I ensure that the project team delivers an acceptable solution, already with the first attempt?

- Supplier (Project Team):
  - How do I get the needed inputs for architecting and designing an accepted solution, even with mediocre requirements?

- Steering Committee:
  - How long is it going to take?
  - How much do we need to invest?

Fricker et al (2010): „Handshaking with Implementation Proposals: Negotiating Requirements Understanding“, IEEE Software.

Identify Patterns

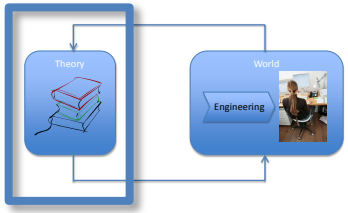


Example

- Research question:
  - How do a customer and a supplier collaborate to avoid requirements misunderstandings?
- Lots of structured and unstructured…
  - …immersion in real-world industrial situations
  - …literature studies
- 1 exploratory case stuy published…
  - …pattern: really bad requirements specifications
  - …pattern: solutions were still successful
  - …but that did not sufficiently answer the question

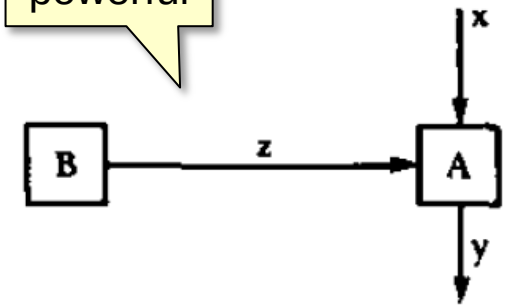
Fricker et al (2006): "A Case Study on Overcoming the Requirements Tar Pit", J.UKM 1, 2. 85-98.

Control Theory



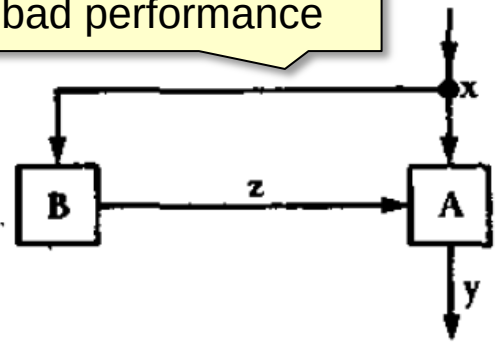
Example

Least powerful

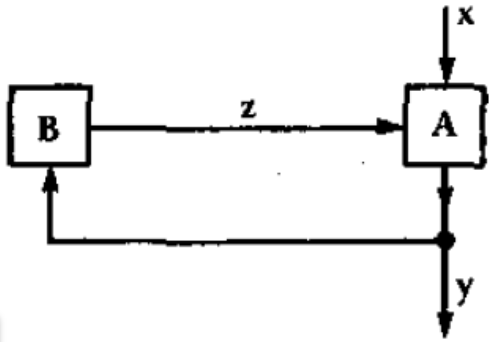


Informationless paradigm

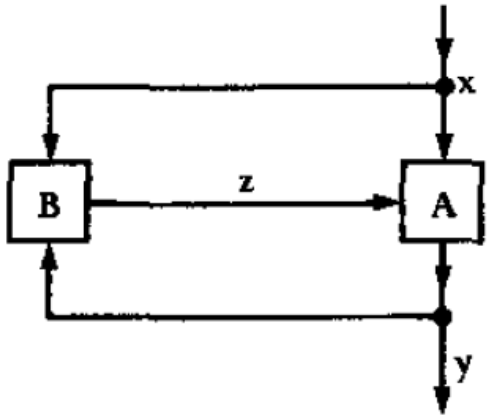
Anticipate to prevent bad performance



Feedforward paradigm



Feedback paradigm



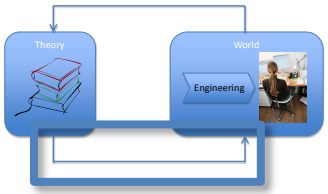
Full–information paradigm

Most powerful

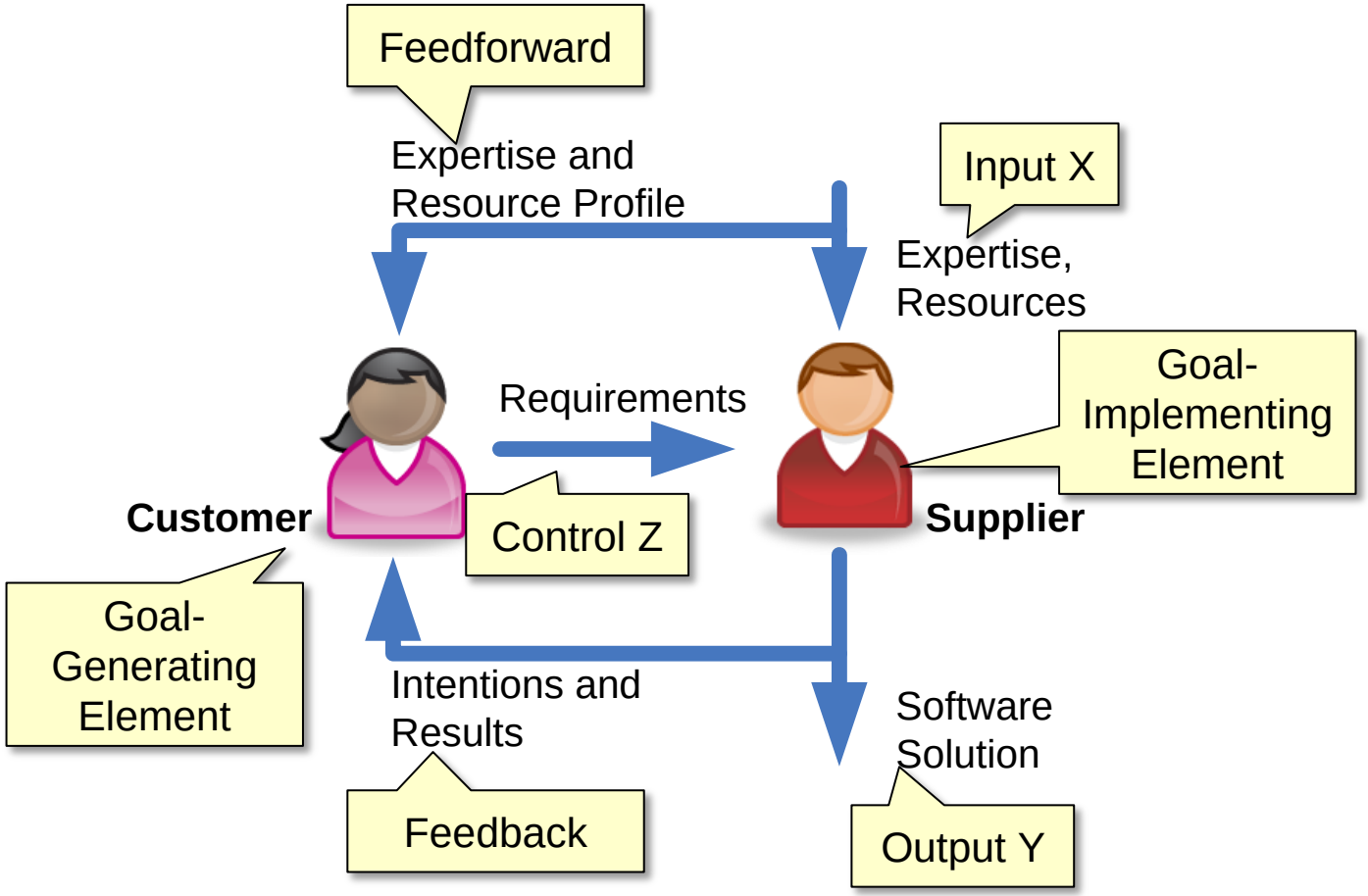
React to improve bad performance

Klir (2001): Facets of Systems Science. Kluwer.

Control Theory Applied to Requirements Communication

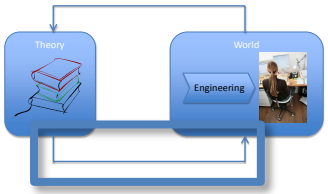


Example



Fricker et al (2008): Goal-Oriented Requirements Communication in New Product Development. IWSPM 2008.

Develop Hypotheses to Validate Theory



Example

H1: The power of the used control paradigm affects contracting success

H1.1: Information about the supplier affects stated requirements

Expertise and Resource Profile

Expertise, Resources

Requirements

Customer

Supplier

Intentions and Results

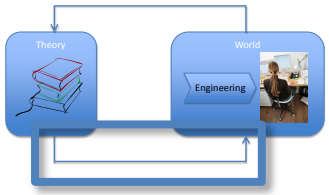
Software Solution

H1.2: Early results affect stated requirements

H0: Customer writes (near-)perfect spects

Fricker et al (2008): Goal-Oriented Requirements Communication in New Product Development. IWSPM 2008.

Check Hypotheses to Validate Theory



Example

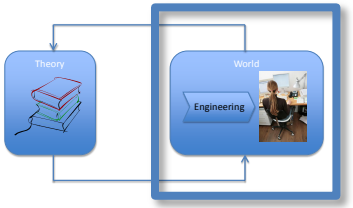
- Artifact analysis and semi-structured interviews with trusting practitioners
  - Product manager: 20yrs experience
  - Architect: 19yrs experience

Green: done
Red: not done

- Informationless
  - We are not good at unambiguity: unambiguity is impossible
  - Formalization points to a solution: formalize only if necessary
- Feedforward
  - Guide development decisions: reference existing development artefacts
  - Save specification effort: specify enough detail but not more than the technical specialist requires.
- Feedback
  - Respond to development interests: development team shares intentions
  - Identify misunderstandings: product manager evaluates planned design
  - Transfer tacit knowledge: product manager criticizes planned design
  - Confirm requirements understanding: accept justified solution

Fricker et al (2008): Goal-Oriented Requirements Communication in New Product Development. IWSPM 2008.

Generalization by Theory



Example

- Given $C_{1..n}$: if X then Y.

Condition (Context)

- Given that a customer wants to obtain acceptable results from a given supplier:
  - Knowledge about the supplier will influence the customer‘s requirements (feedforward)
  - Early development results from the supplier will influence the customer‘s requirements (feedback)
  - The customer does *not* write specifications of perfect or near-perfect quality (information-less)

Conclusions (Candidate Laws)

Fricker et al (2008): Goal-Oriented Requirements Communication in New Product Development. IWSPM 2008.

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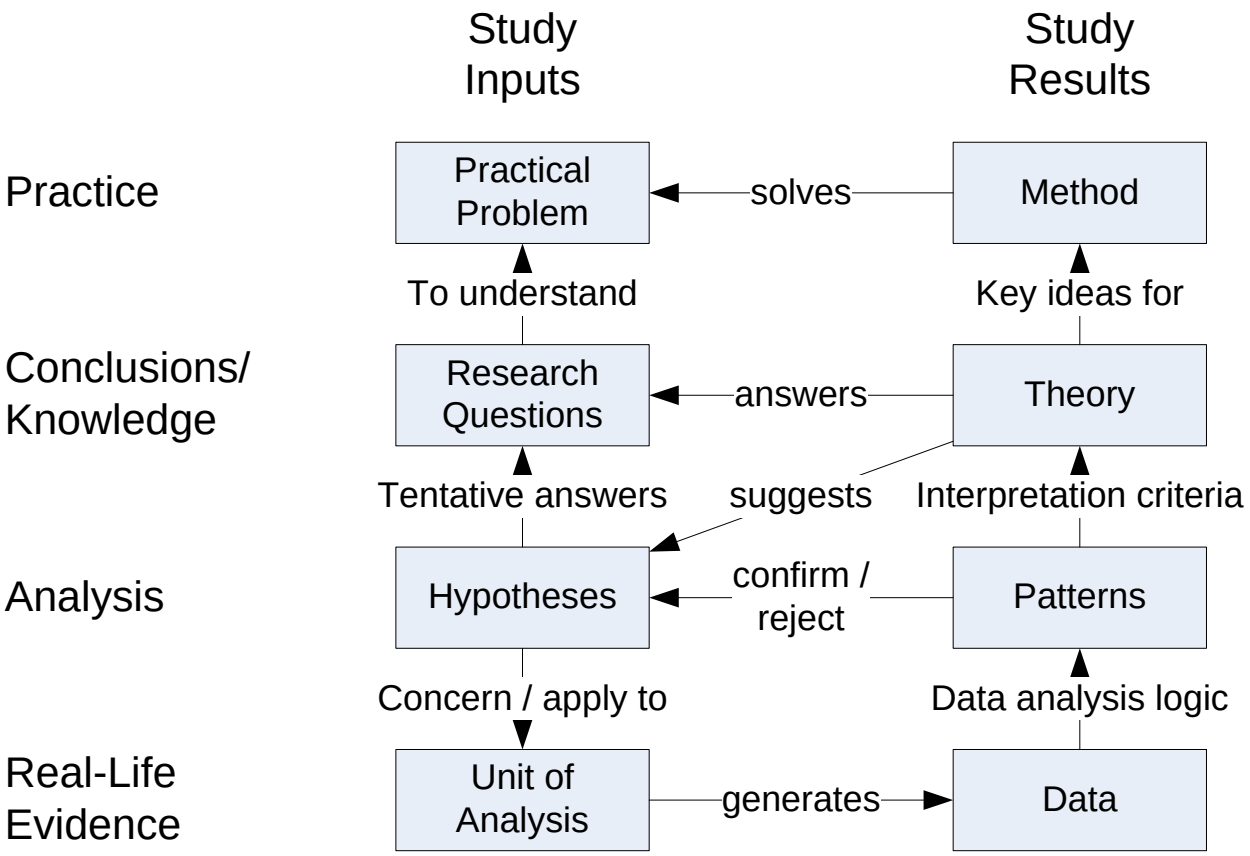
Case Study Variants

- Purposes
  - Describe a real-life situation or an intervention
  - Explain causal links in real-life interventions
  - Illustrate given topics within an evaluation
  - Enlighten situations where the intervention has not clear, single set of outcomes
- Scope of investigation
  - Singe- and multiple-case studies
  - Comparative case studies
- Type of evidence
  - Quantitative and qualitative

Research Design

- Research design is the logical model of proof that allows the researcher to draw inferences for corroborating or refuting a theory.
- Purpose: avoid situation that collected data is meaningless
- Elements of case study research design
    - Unit of Analysis (the „Case“)
    - Theory and Hypotheses
    - Case Study Type
    - Quality Management

Research Design



Case Study Types

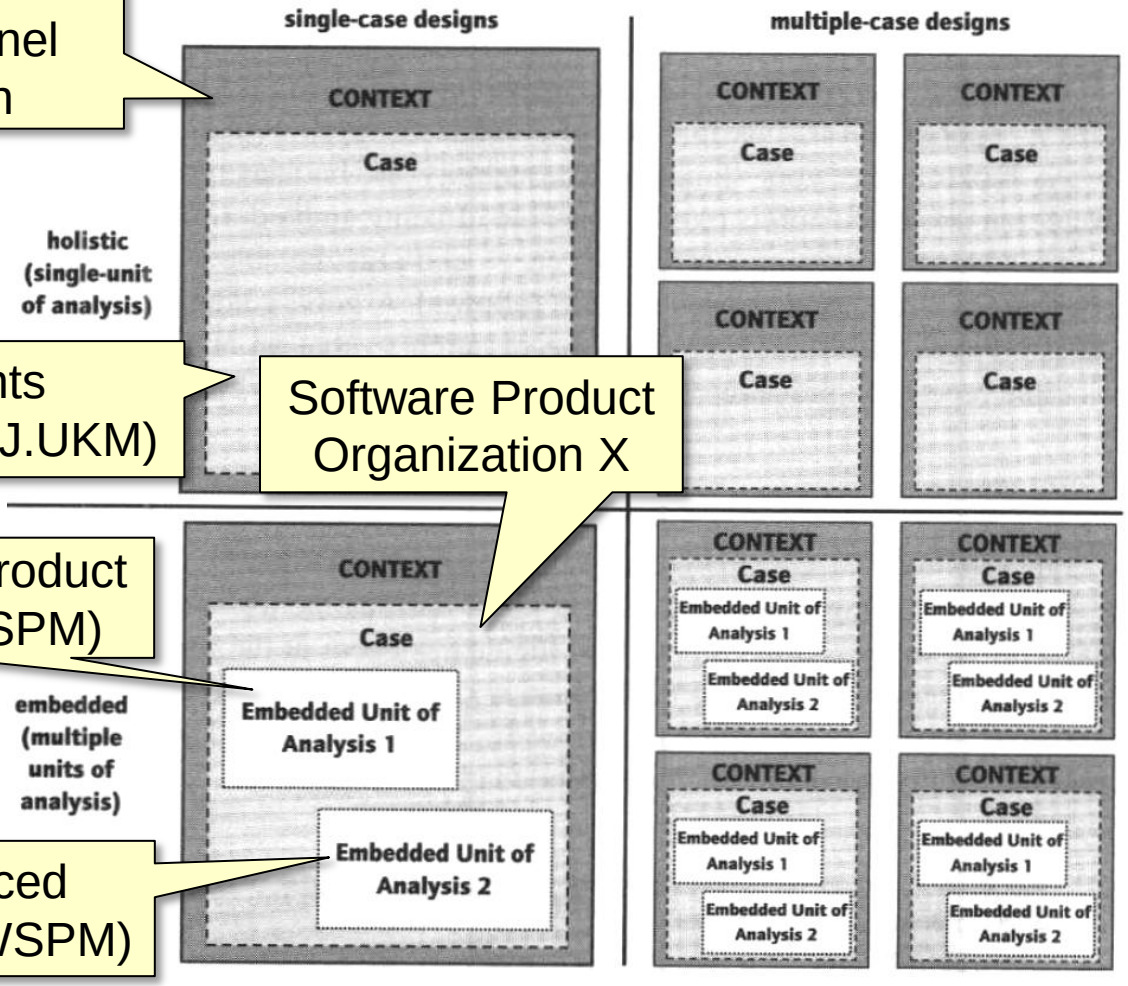
Organization with little personnel fluctuation

Requirements Communication (J.UKM)

Experienced Product Manager (IWSPM)

Experienced Architect (IWSPM)

Software Product Organization X



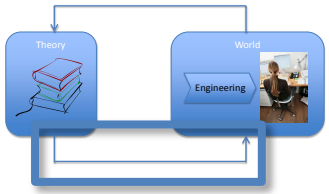
Yin (2009): Case Study Research: Design and Methods. Sage.

Theory Development

- Theory is expressed by statements like
  „$C_{1..n}$: X $\Rightarrow$ Y“ (theory) and
  „$C_{1..n}$: not (X $\Rightarrow$ Y) “ (dismissed theory)

- Theory „$C_{1..n}$: X $\Rightarrow$ Y“:
  „The case study shows why in an organization with little personnel fluctuation business and development use feed-forward and feedback to communicate requirements communication.“
- Dismissed Theory „$C_{1..n}$: not (Z $\Rightarrow$ Y)“:
  „The case study shows why in an organization with little personnel fluctuation (near) perfect requirements specification is perceived to be inefficient and ineffective for requirements communication.“

Data Analysis for Checking Theory



Example

Rival theory

Pattern matching: what does the theory predict, what not?

- Informationless
  - We are not good at unambiguity: unambiguity is impossible
  - Formalization points to a solution: formalize only if necessary

Control theory

- Feedforward
  - Guide development decisions: reference existing development artefacts
  - Save specification effort: specify enough detail but not more than the technical specialist requires.

Control theory

- Feedback
  - Respond to development interests: development team shares intentions
  - Identify misunderstandings: product manager evaluates planned design
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  - Confirm requirements understanding: accept justified solution

Explanation: „why?“

Observation: „what?“

Fricker et al (2008): Goal-Oriented Requirements Communication in New Product Development. IWSPM 2008.

Elements of Research Design

- Research questions (study questions)
  - How and why questions
  - Motivated by the practical problem addressed by the research
- Hypotheses (study propositions)
  - Tentative answers to the research questions
  - Informed by theory
- Unit of analysis
  - Definition of what the „case“ is: e.g. people, decisions, projects, processes, etc.
  - Definition of what the case and context is
  - Definition of relevant information to be collected
  - Informed by research questions and hypotheses
- Data analysis logic
  - Pattern matching, explanation building, time-series analysis, logic models, cross-case synthesis
  - Challenge is to collect just enough of the right data
- Interpretation criteria
  - Statistics (rare), address rival explanations for findings (anticipate and enumerate them)

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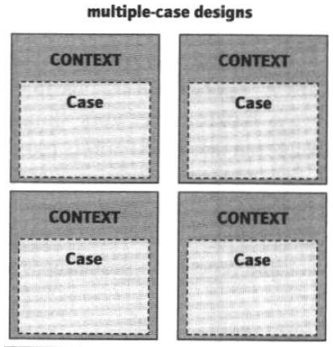
Case Study Protocol



- Goal: enable replication (reliability threat)
- Contents

Introduction	• Research questions and hypotheses • Theoretical framework • How to use the case study protocol
Data Collection	• Names of sites to be visited and contact people • Data collection plan: when, what, how • Prepration prior to site visits
Report Outline	• Table of Contents, Format, and Audience
Data Collection Instruments	• Questionnaires (e.g. for interviews) • Checklists (e.g. for artefacts to be collected) • Etc.

Yin (2009): Case Study Research: Design and Methods. Sage.

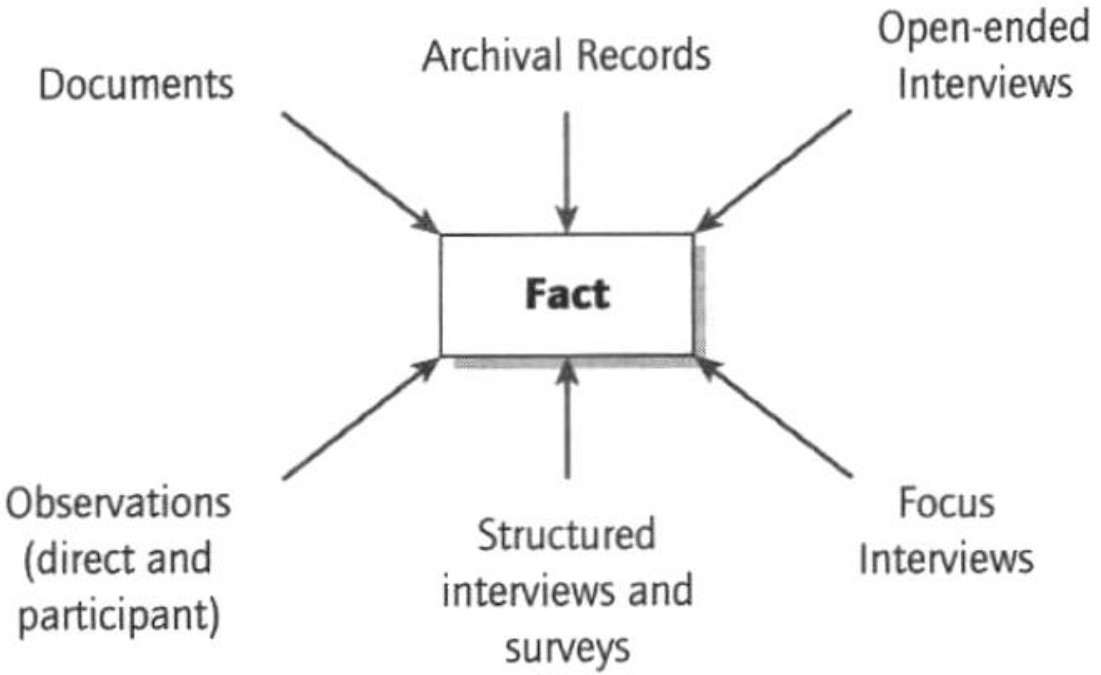
Sources of Evidence: Common Data Collection Techniques

- Participant-Observation (in some situations called „action research“)
  - Immerse with what really is being done:
    Be a part of the case
- Direct Observation
  - Understand what really is being done:
    Look over shoulders and record (paper, voice, video) activities
- Interviews
  - Understand the opinions of practitioners:
    Usually semi-structured interviews
- Physical Artefacts
  - Understand the objects that are relevant in the case:
    Analyze things (physical office layouts, machines, etc.)
- Documentation
  - Understand what really has been done:
    Analyze work results such as plans, documents, etc.
- Archival Records
  - Understand what others have observed:
    Analyze reports about the units of analysis

Yin (2009): Case Study Research: Design and Methods. Sage.

Three Principles of Data Collection

- Goal: ensure construct validity and reliability
- Multiple Sources of Evidence
  - Triangulate to converge to a finding:
    Use multiple data sources, researchers, perspectives, and data collection methods



Yin (2009): Case Study Research: Design and Methods. Sage.

3 Principles of Data Collection (cont.)

- Create Case Study Database
  - Collected data: notes, voice files, transcriptions, documents, spreadsheets with analysis results…
  - Case study report: article, thesis, book…
- Maintain Chain of Evidence
  - Allow an external observer to follow the derivation of your evidence from initial research question through data to conclusion
  - In the following sections of your report:
    - Study design and planning: explain how objectives, theory, questions, hypotheses, units of analysis, and data collection relate to each other
    - Narrative, data analysis, discussion, and conclusions: establish full traceability from data (cited practitioner statements, document extracts) to conclusions about theory

Yin (2009): Case Study Research: Design and Methods. Sage.

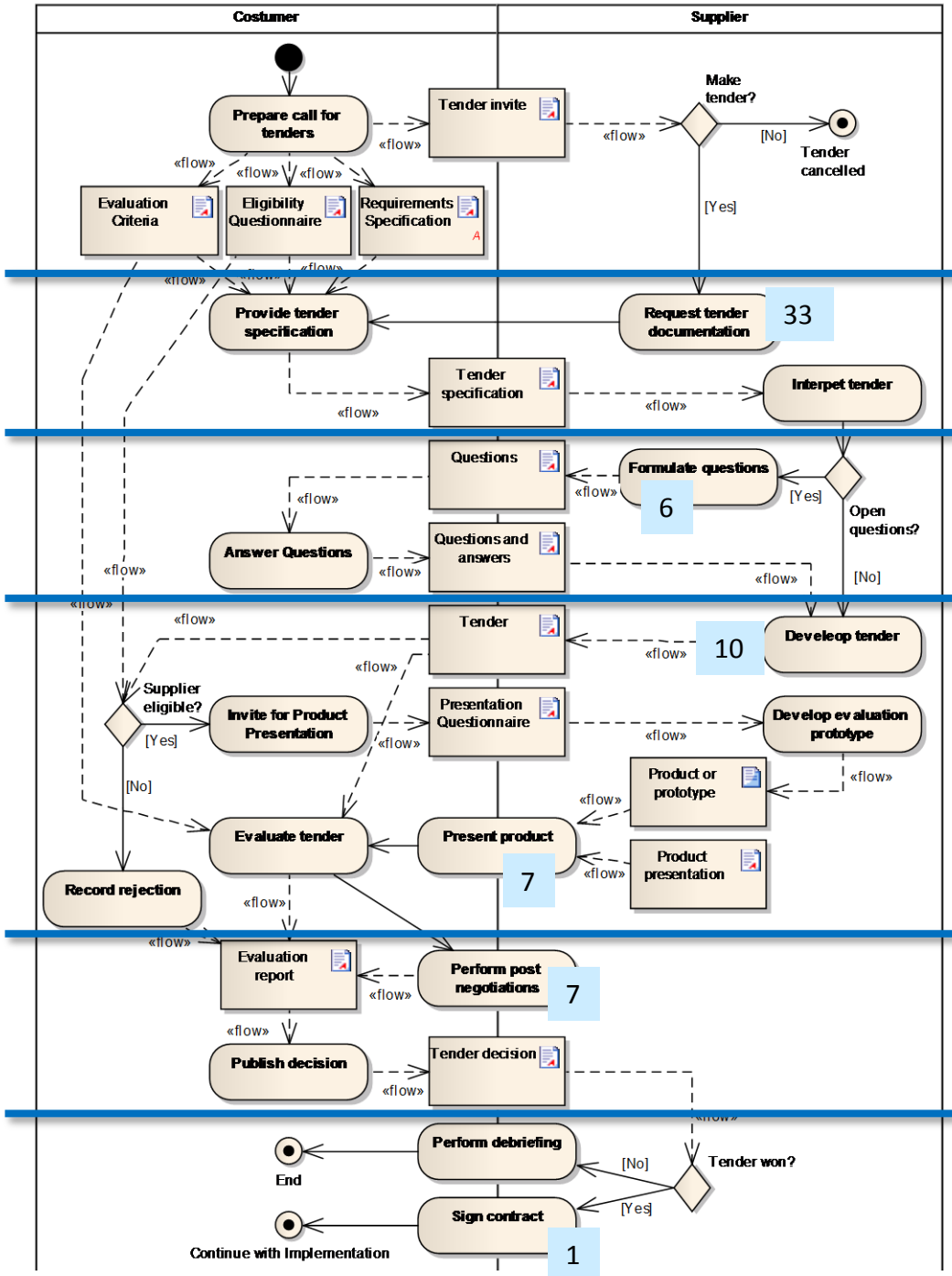
Data Analysis Techniques

- Pattern Matching
  - Compare empirical results with those predicted by the theory
  - Investigate both positive and negative predictions
  - Investigate predictions by all theories (also the rival ones)
- Explanation Building
  - Provide an argumentation of how data strengthens or weakens theory
  - Combine how and why questions in interviews
- Time-Series Analysis
  - Document the chronology of events
  - Trace variables over time to do pattern matching with theory
- Logic Models
  - Show how an intervention leads to an immediate outcome, then to an intermediate outcome, then to the final outcome
- Cross-Case Synthesis

Yin (2009): Case Study Research: Design and Methods. Sage.

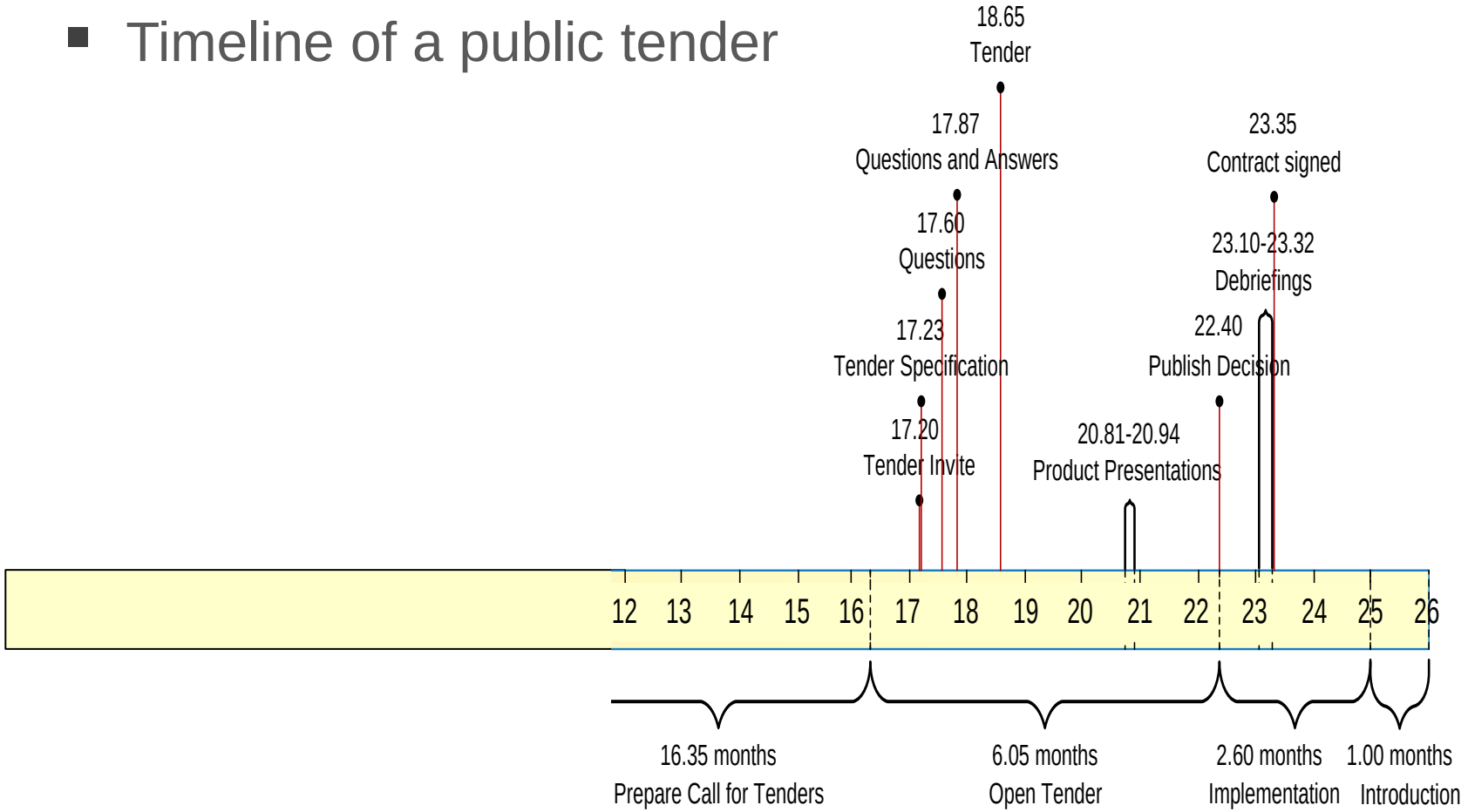
Logic Models

- Structure of a public tender
  - RFP
  - Tender Specification
  - Clarification
  - Solution Demonstration
  - Decision-Making
  - Conclusion



Chronology: Example

- Timeline of a public tender

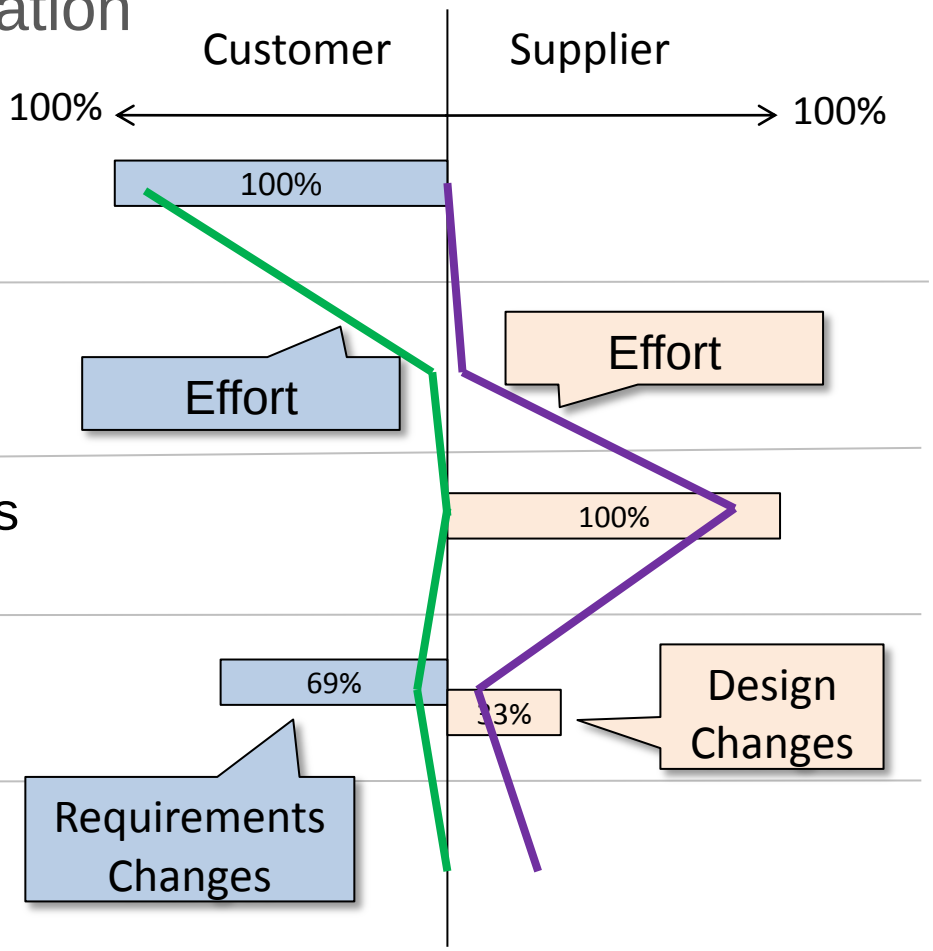


Fricker (unpublished)

Trace Variables: Example 2/2

- Requirements Communication

- PO1: Customer specifies Requirements
- HO: Customer hands Requirements over to Supplier
- PO2: Supplier analyzes Requirements and System
- NE: Both negotiate Implementation Proposals
- CO: Both document Negotiation Results



Fricker, Glinz (2010). "Comparison of Requirements Hand-Off, Analysis, and Negotiation: Case Study", RE'10.

Data Analysis Tools

- Tools that help to manage and analyze data:

  http://www.atlasti.com/
  http://www.researchware.com/products/hyperresearch.html
  http://www.qsrinternational.com/products_nvivo.aspx

Quality of Case Studies

- Construct validity
  - Identify correct operational measures for the concepts being studied
- Internal validity (for validation, not exploration)
  - Seek to establish a causal relationship
- External validity
  - Define the domain to which the study's findings can be generalized
- Reliability
  - Demonstrate that the study can be repeated with the same results

Yin (2009): Case Study Research. Sage.

Quality Assurance Tactics for Case Studies

Test	Case Study Tactic	Research Phase
Construct Validity	Use multiple sources of evidence	Data collection
	Establish chain of evidence	Data collection
	Informants review draft report	Composition
Internal Validity	Match patterns	Data analysis
	Build explanations	Data analysis
	Address rival explanations	Data analysis
	Use logic models	Data analysis
External Validity	Single-case: use theory	Research design
	Multi-case: use replication logic	Research design
Reliability	Use case study protocol	Data collection
	Develop case study database	Data collection

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Important Skills for a Case Study Researcher

- During whole case study process
  - Be adaptive and flexible:
    Learn and react to the unexpected
  - Focus on the study‘s purpose:
    Have a firm grasp of the issues being studied
  - Avoid bias:
    Be ready to accept all possible study results

- During data collection
  - Ask good questions:
    Understand literature (and if possible the practice) in advance
  - Be a good listener:
    Use all senses (e.g. body language during interviews)

Yin (2009): Case Study Research. Sage.

Presentation and Packaging

Table of Contents

1. Introduction
2. Problem Statement
3. Case Study Design and Plan
4. Narrative
5. Data Analysis
6. Interpretation of Results
7. Discussion and Conclusions
8. Appendixes

Knowledge Developed with Case Study Research

Experiments

- Positivist (or "Post-positivist")
  - Knowledge is objective
  - "Causes determine effects/ outcomes"
  - Reductionist: study complex things by breaking down to simpler ones
  - Prefer quantitative approaches
  - Verifying (or Falsifying) theories

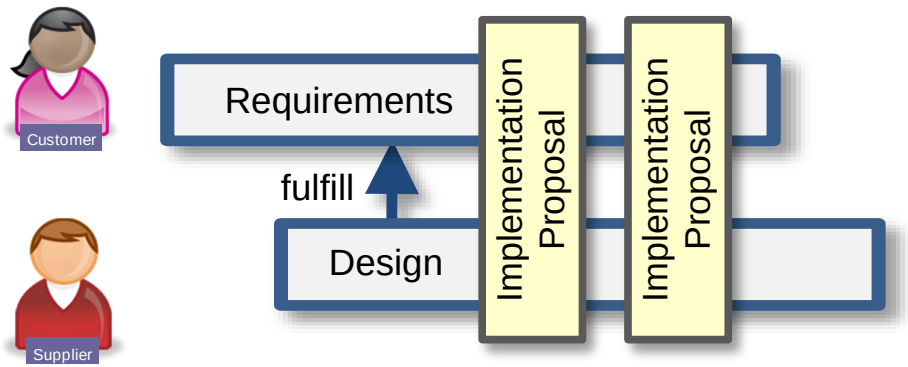
Case Study Research

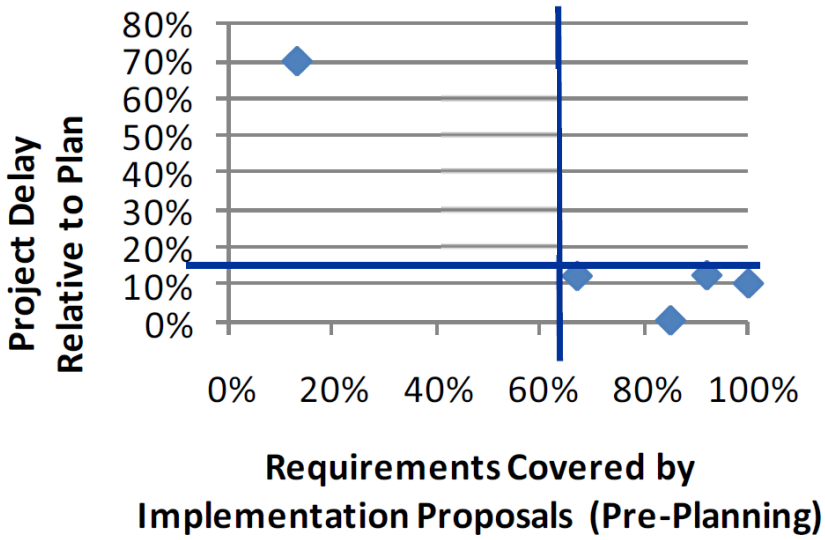
- Constructivist/Interpretivist
  - Knowledge is socially constructed
  - Truth is relative to context
  - Theoretical terms are open to interpretation
  - Prefer qualitative approaches
  - Generating "local" theories

Easterbrook (2007): Empirical Research Methods in Requirements Engineering. Tutorial at RE'07.

Ensuing Steps of the Primer Case

- Method Development
- Multi-Case Evaluation of Method





- „This has been one of the top process improvements from the last five years.“

  Per Skytt, Development Manager, ABB Power Products

Fricker et al (2010). "Handshaking with Implementation Proposals: Negotiating Requirements Understanding", IEEE Software 27, 2.

Literature

- R. Yin (2009):
  Case Study Research – Design and Methods.
  Sage.