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Avoiding the tar pit of numbers

Challenges of Statistical Analysis with Software Engineering Data

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Agenda

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- Background
- Data Issues
- Statistical Challenges
- Summary

Background

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- Many forces encourage increased use of statistical analysis in management and improvement of software (and other) engineering processes, e.g., CMMI, Six Sigma
  - Process Performance Models
- Bad analysis leads to bad decisions – correctness is a CMMI appraisal issue

What is Statistical Analysis?

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- Building mathematical models based on data
- Using those models to evaluate or estimate measurable phenomena
- Quantifying the uncertainty associated with models and decisions

A model underlies every statistical analysis technique

Data Issues

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- Alignment
- Quality
- Quantity
- Linkage

Alignment

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- Data and analysis must be linked to something important to be useful, i.e., aligned with goals
- Many organizations only start to approach goals systematically at higher levels of maturity

Establish objectives before anything else.

Quality

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- Most measurement involves humans
  - Misinterpretation is common
  - Motivation is important
- Quality of data is not really known until analysis is attempted

Good definitions, incremental implementation, and early feedback help.

Quantity

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- Processes often not designed to be measured (or managed)
  - Large activities => infrequent data
  - Lean process designs make more data available
- Amount of data needed depends on analysis technique (degrees of freedom)
- Experiments (Six Sigma) versus Measurement Programs (CMMI)

Large amounts of data are not always necessary for meaningful analysis.

Linkage

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- Individual databases are often constructed for specific purposes (e.g., peer reviews, estimation, problem reports, earned value) by different groups
- Many important problems require consideration of data from multiple sources
- Important potential linkages include: project, phase, artifact

Define a “master plan” encompassing all repositories.

Statistical Challenges

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- Distributions, Types, and Scales
- Significance and Substance
- Interpreting Causality

No silver bullet – find the right technique for your data.

Distributions, Types, Scales

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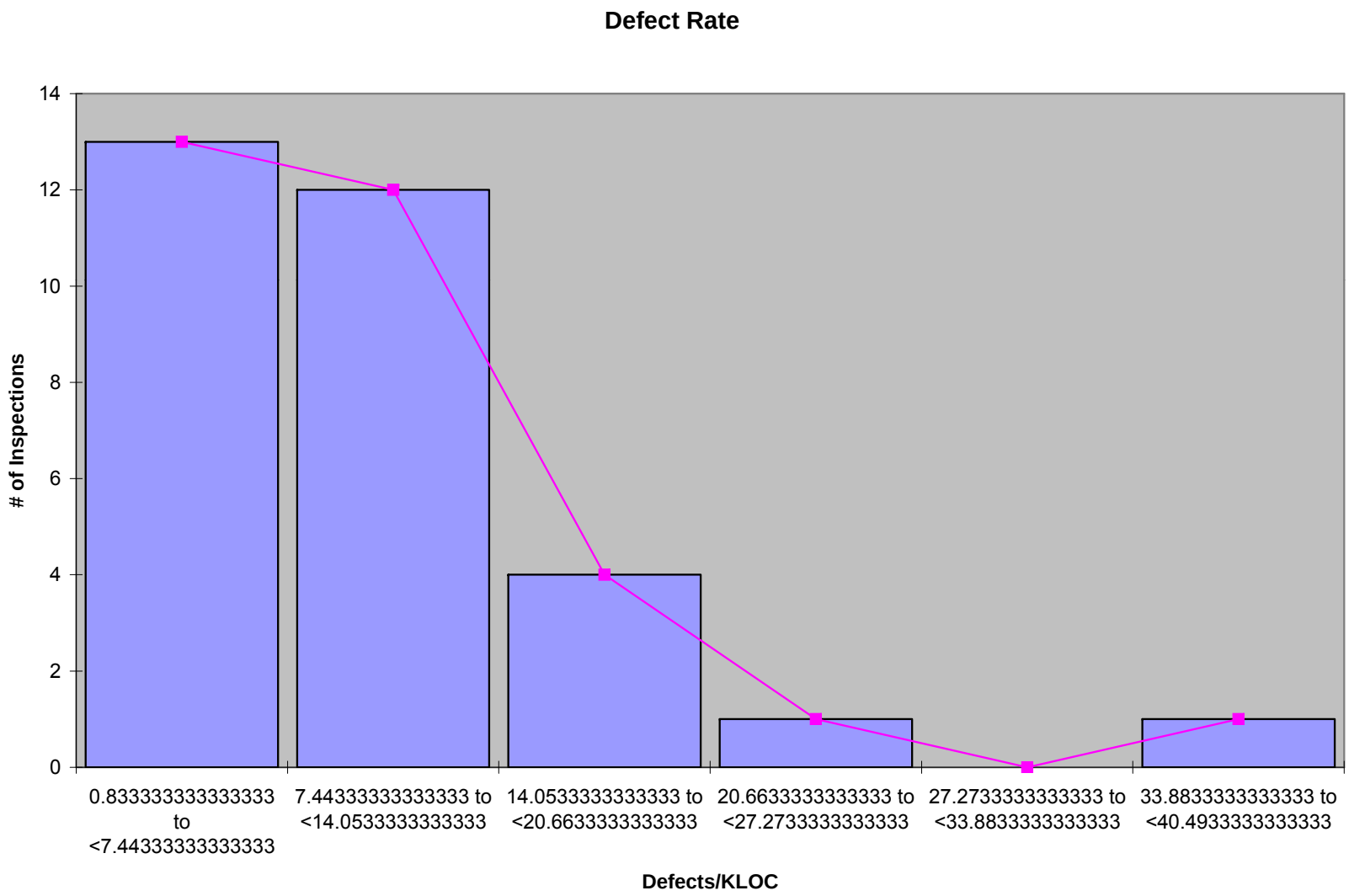
- Probability density function (continuous) or probability distribution (discrete)
- Nominal and ordinal data cannot be normally distributed
- Distributions of data from interval and ratio scales be observed (e.g., histogram) or inferred
  - Normal
  - Poisson
- Distribution of sample means may help (≠ law of large numbers)
- Avoid transformations

Look at the data before attempting statistical analysis.

Histogram Indicating Poisson Distribution



Examples of Statistical Techniques

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	Second Measure		
First Measure	Nominal	Ordinal	Interval and Ratio
Nominal	Chi-square	Friedmann ANOVA	Normal ANOVA
Ordinal		Spearman Correlation	Spearman Correlation
Interval and Ratio			Regression Pearson Correlation

Substance and Significance

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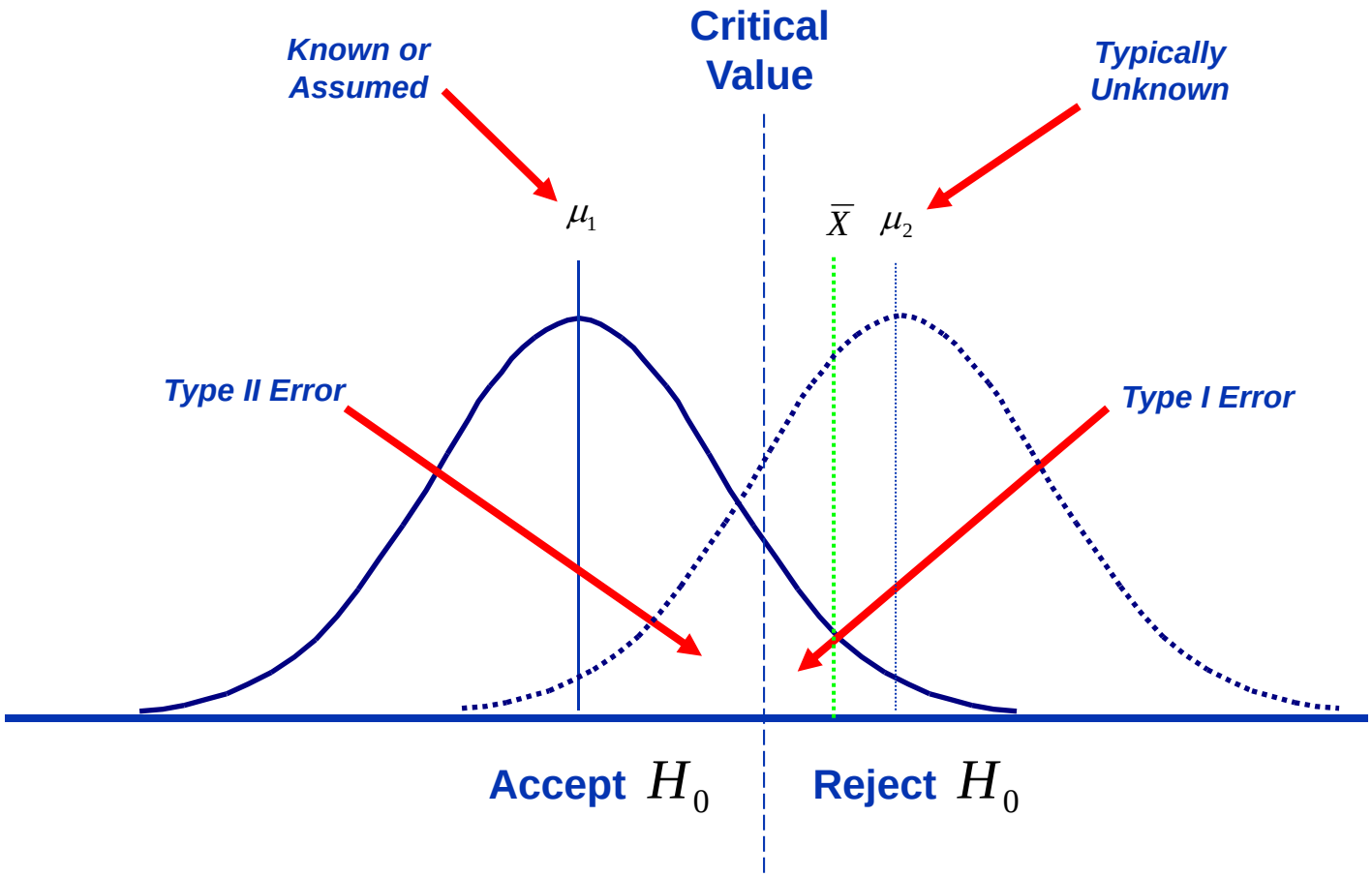
- Not all significant relationships (p) are substantive
- Consider magnitude of difference or use r^2 to assess importance of regression relationships

Look for important relationships first, then try to show them as significant.

Statistical Decision-Making



Conditions for Causality

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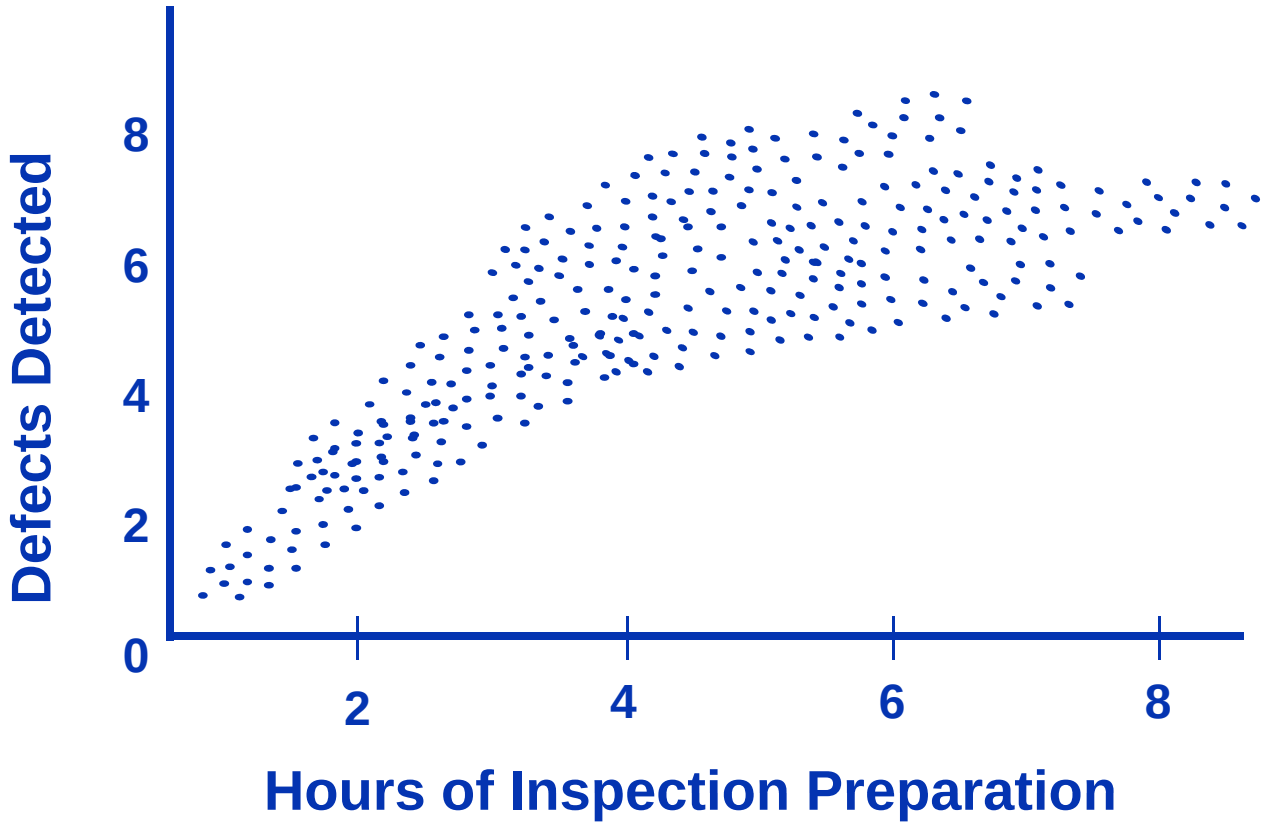
- Association
- Cause strictly precedes effect
- Mechanism for interaction

Many people has an instinctive understanding of causal analysis, which is wrong.

A Causal Relationship?



Summary

- Statistical analysis is about modeling
- Nature of data determines the appropriate analysis technique
- Data collection must be planned with intended analysis in mind
- Use a systematic approach to causal analysis
- Learn and adapt