Seven Basic Quality Tools

Objectives

- Introduce some basic quality analysis and control tools for gaining insight from metrics
  - Seven “Basic” Quality Tools
  - Plus a few “additional” tools

- These are tools to ...
  - Analyze quality metrics data to gain insight on attainment of quality goals and opportunities for quality improvement
  - Focus quality assessment and improvement activities on high-value results

The Seven Basic Tools

- Checklists (Checksheets)
- Pareto Diagrams
- Histograms
- Run Charts
- Scatter Diagrams (Scatter Plots)
- Control Charts
- Cause-and-Effect (Fishbone) Diagrams

What Are These Tools?

- Simple techniques to:
  - Track quality performance and trends
  - Identify the existence of quality problems
  - Analyze and gain insights into the causes and sources of quality problems
  - Figure out which problems to address
  - Help eliminate quality problems
    - Defect prevention, not just detection and correction
- Basic knowledge for anyone interested in quality, engineering problem solving, and systems design
  - Probably already familiar with most of these

Why Exactly Seven Tools?

- Kaoru Ishikawa promoted the notion of seven basic tools that could be used to address quality
  - Designed for manufacturing environments, but applicable to engineering & management, too
- There are other very useful tools:
  - Templates, workflow automation
  - Pie charts and other graphical representations
  - Relationship diagrams, tree diagrams, etc. ("Seven new quality tools")
  - System dynamics diagrams and influence diagrams
- We learn a basic subset here, others left to "lifelong learning"
  - Corporate training often introduces/uses quality tools & techniques
  - See the American Society for Quality (http://www.asq.org/)

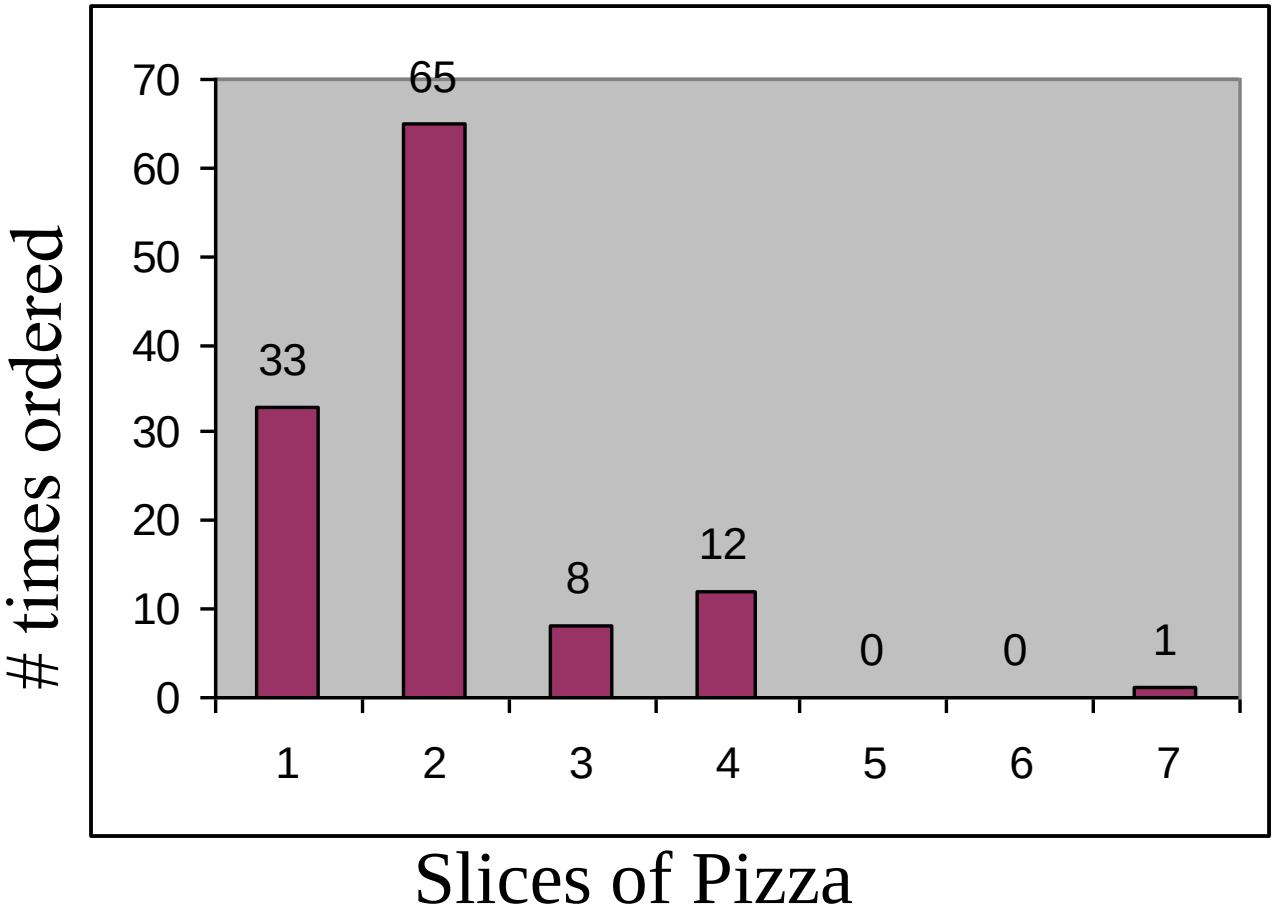
What to Learn About Each Tool

- What is the tool?
- How is it used?
- For what purposes is it useful?
- What value does it add?
- What are its limitations?
- How can it be used effectively?

Histogram

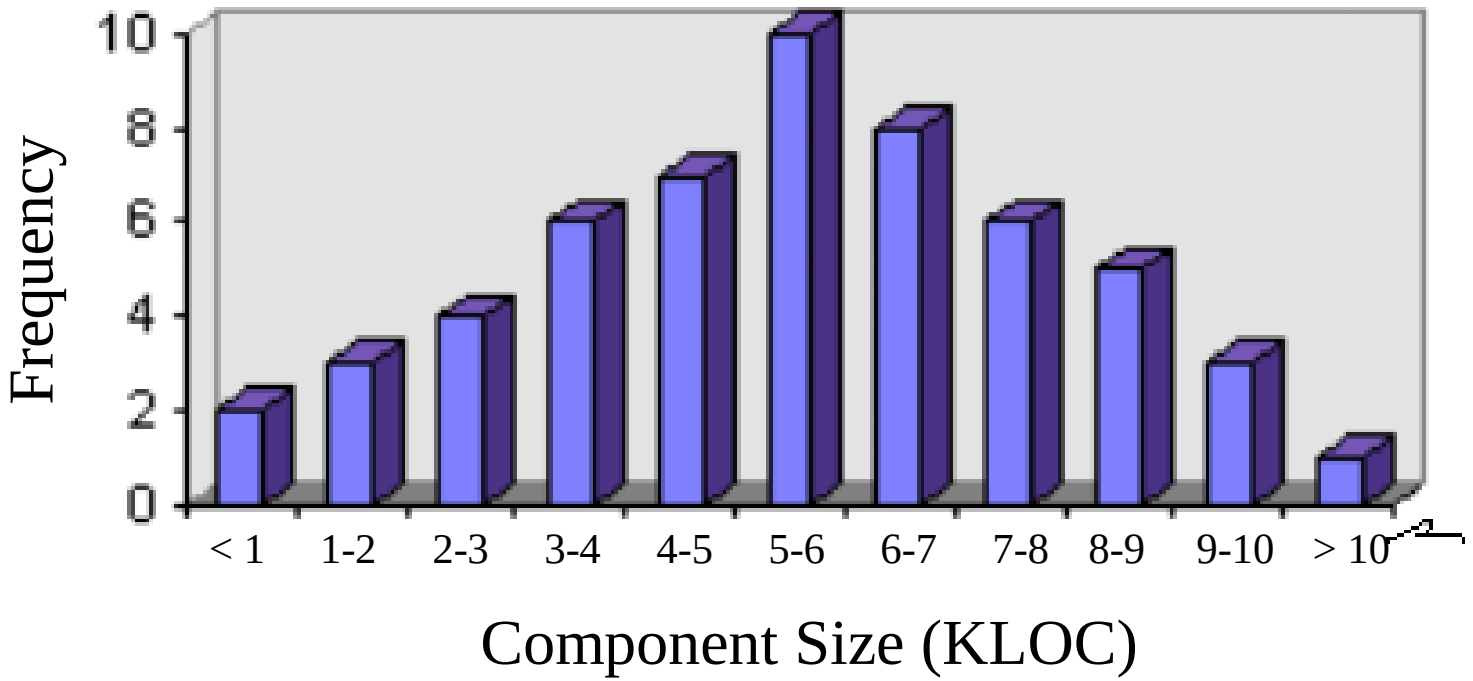
- A bar graph showing frequency counts
- X axis often a nominal or ordinal scale; Y axis is how often that X value occurred in measurements or observations
- Use/value: Easy to see relative magnitudes / frequencies
  - Sometimes low frequency items are of interest
    - For example, dissatisfied customers: histogram may "minimize" these high-impact but infrequent occurrences
  - Can use different color or other ways to highlight importance
- Sometimes multiple bars for each item (e.g. last year / this year), to show trends and changes
- Pie chart representation useful if these are parts of a whole
  - Not very good if there are several low-frequency items of interest
- Sometimes cumulative frequency line added to show "total at or below this level" – useful if X axis is ordinal scale

Histogram Example: A Pizza Shop



From http://www.freequality.org

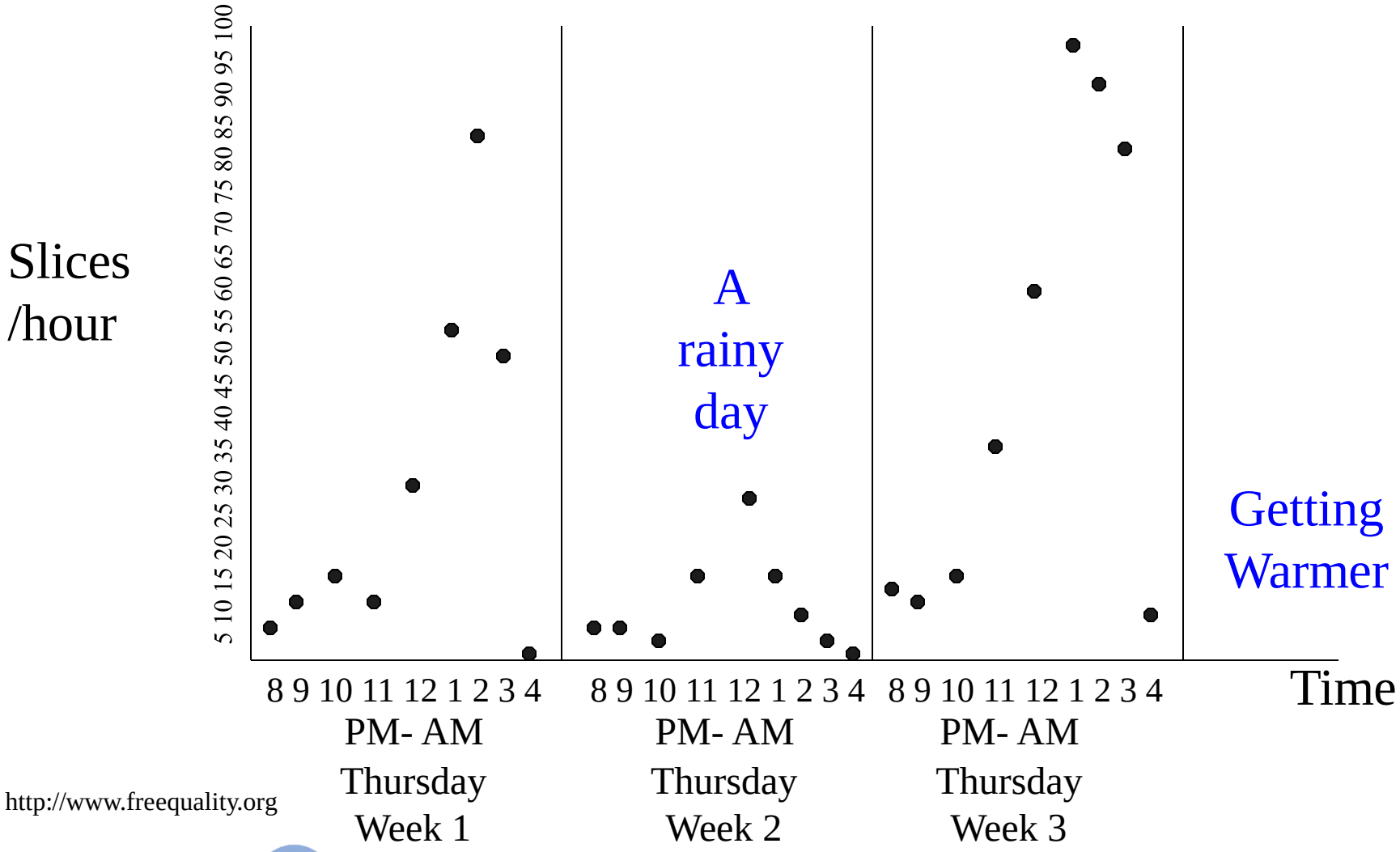
Example: Distribution of Component Size



Run Charts

- Plot of some measurement/metric vs. (usually) time
  - Use this when X axis is interval or ratio scale, such as project time, component size, team size, etc.
- Often used to show trends over time
  - Easier to spot overall upward or downward trend, or cyclical variations and other patterns
- Visually separate random from significant variation
  - Major spikes or valleys are triggers for explanation, investigation, or action
- Value: Identification of problems, trends, unexpected good results (may learn a lot from these)

Run Chart Example for Pizza Shop



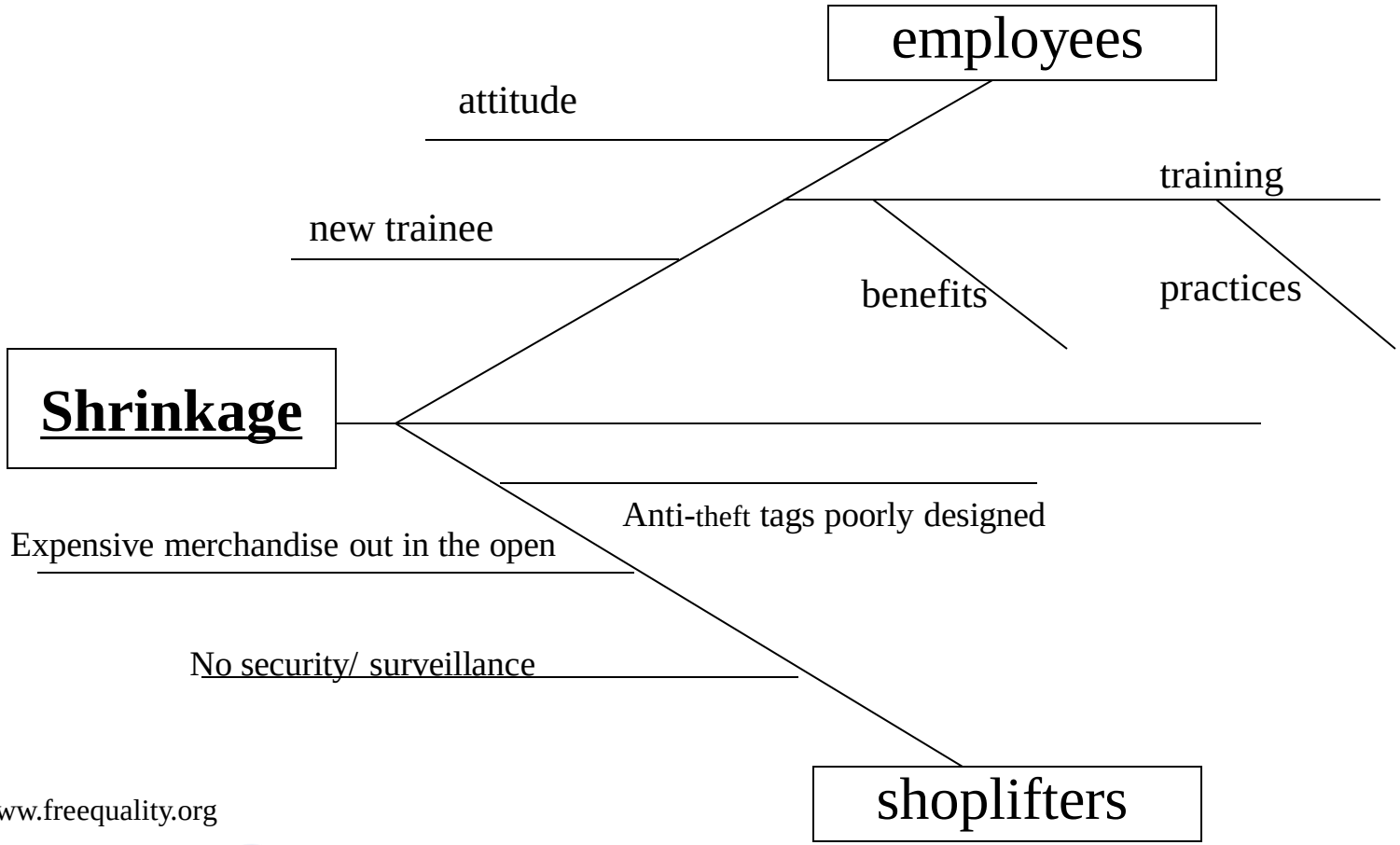
From http://www.freequality.org

Cause-And-Effect (Fishbone) Diagram

- Diagram showing hierarchical structure of causes that contribute to a problem or outcome:
  - Problem of interest forms the backbone
  - Spines are causes that contribute to the problem
  - Spines may have bones that represent its contributory factors and so on
- Used in brainstorming to diagram and identify various possible factors contributing to a problem, and to identify causal sequences (A causes B causes C) and root causes
  - Very simple but extraordinarily useful tool
- Initially both minor factors (that occur rarely or contribute very little) and major causes may all get listed

Example Fishbone Diagram

- Example: High Inventory Shrinkage at local Drug Store



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Design Inspection Example from Tian Textbook

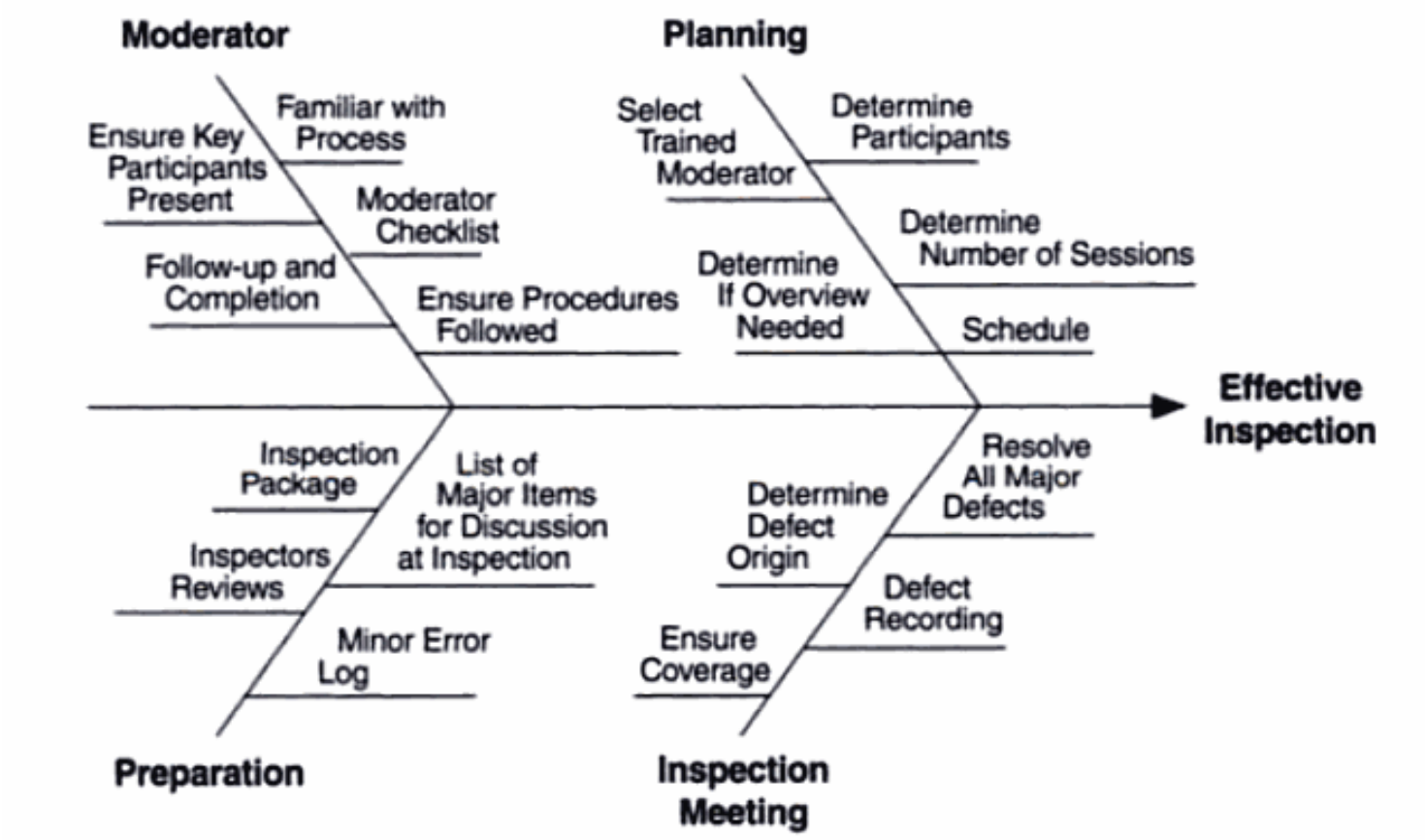
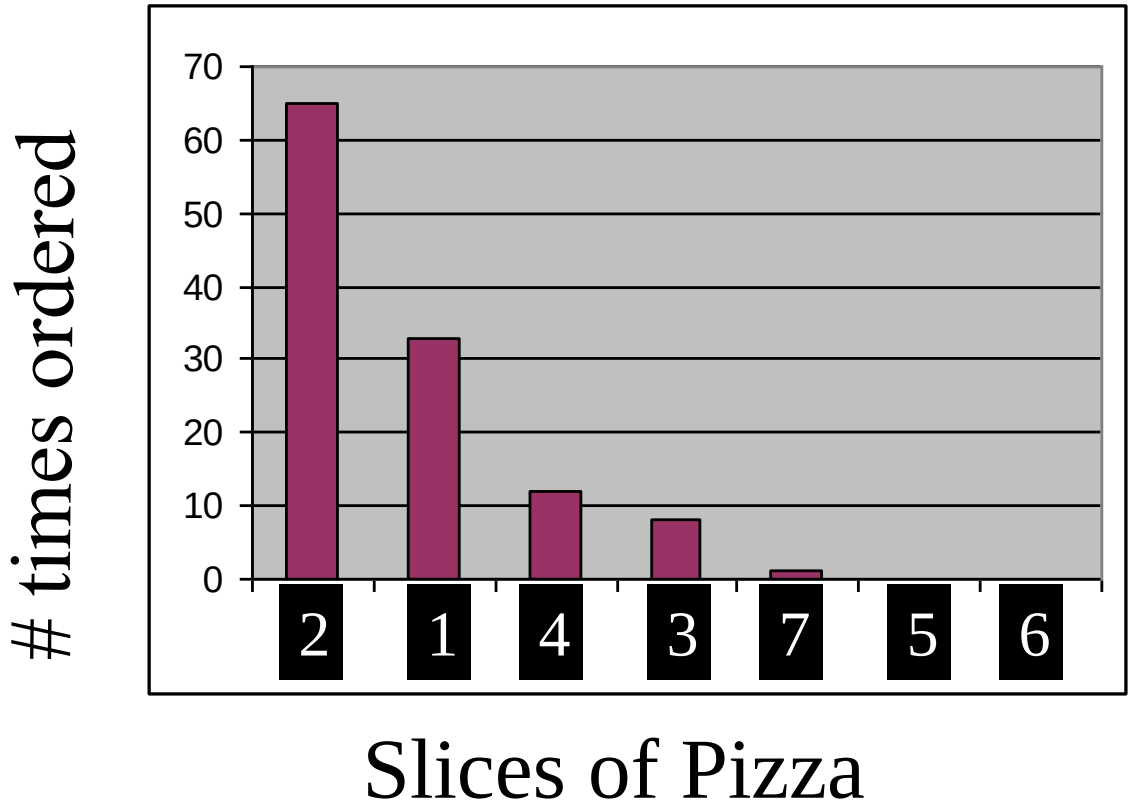


FIGURE 5.16
Cause-and-Effect Diagram of Design Inspection

Pareto Diagram

- Histogram arranged by decreasing frequency
- Used to identify causes that contribute most to the problem
- After fishbone analysis, may do data gathering to figure out the frequency with which each cause contributes to the problem
  - In software, review reports are good data sources
- Plot histogram, identify the major causes
- Based on Juran's Pareto Principle – the 80/20 rule
  - "80% of the effects come from 20% of the causes"
  - Indicates general principle that some causes likely to be a lot more significant than others
- Highest cost-benefit from addressing the most significant problems
  - Less significant problems may barely be worth addressing

Pizza Shop Example



From http://www.freequality.org

Four Basic Defect Prevention Tools

- Checklists
- Templates
- Processes
- Workflow automation

Checklists

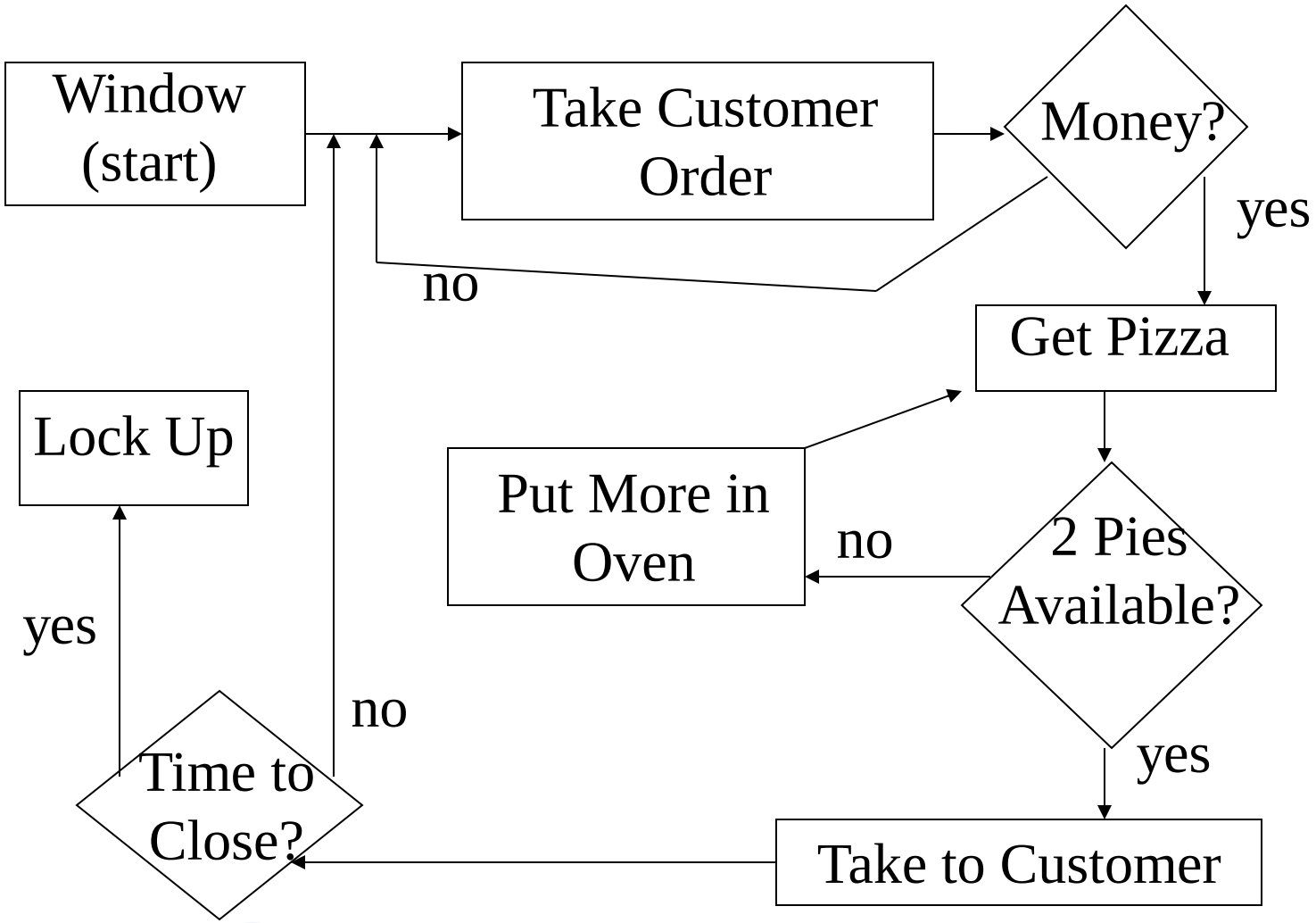
- Once we identify the causes of problems, how do we eliminate them?
  - Checklists are simple and incredibly effective at preventing & eliminating defects on repetitive tasks
    - To Do lists, “did you ...” on bill payment envelopes, etc.
- Capture knowledge about common problems and how to avoid them
- Can be used in review processes to identify problems
- Lightweight: low additional effort to use (not zero!)
- Checklists that become too long lose value (use Pareto analysis!)

Flowcharts (Process Diagrams)

- Flowcharts show sequencing of activities and decisions
  - Depiction of processes for doing things
- Streamline the flow of activities
- Capture knowledge about how to perform activities effectively
- Eliminate problems due to missed activities and badly sequenced activities
- Can be used to analyze and implement improvement ideas:
  - Good processes can save work and avoid problems
    - Less than zero cost for improving quality
    - Should always be the goal of process design

Flowchart Example for Pizza Shop

From http://www.freequality.org



Templates (A Type of "Checklist")

- Templates are another near zero-cost defect elimination mechanism
  - Pre-created document structure
  - Often pre-populated with "boilerplate" stuff: standard explanations, disclaimers etc.
  - Avoids problems due to missing information, incompleteness
    - Avoids problems in activity for which the document is the output
    - Need to fill in form, so get the data/do the activity!
- Problems with templates:
  - Not all sections are always applicable; may sometimes want different structure
  - Can constrain people from doing what they need to
  - Can lead to "automaton" mode where people just fill in form without thinking if that's the most appropriate thing to do
- Make templates as guidelines, not "set in stone" forms

Are you using the document outline of your project as a checklist?

Workflow Automation

- Creation of computerized tools that streamline activities, such as automated check-in and build, automated testing
  - Implements process, templates
  - Eliminates many kinds of defects
  - Saves effort
- Flexibility is often a major problem
  - If the needs are different from what the tool supports, can't do it at all (or significant work-arounds)
  - Designing flexible tools which automate workflow is a major technical challenge

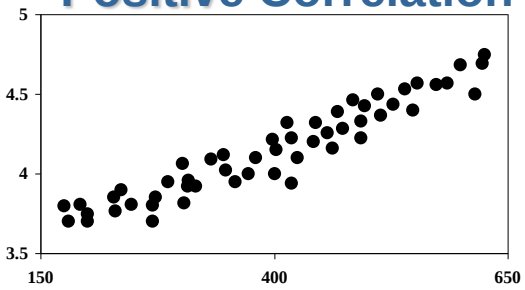
Scatter Diagram

- Used to determine whether there is really a relationship between two variables
  - Fishbone cause-effect diagramming identifies possible causes
  - Doing a scatter plot can show whether the proposed cause and its effect are correlated
    - Visual plot can show degree of correlation, non-linear correlations
      - Often annotate fishbone diagram to show whether a possible cause-effect has been shown to be statistically correlated
    - Linear correlations if most points are along a straight line
    - Poor (linear) correlation if points scattered all over
- Remember: correlation does not imply a causal relationship!

Scatter Diagrams

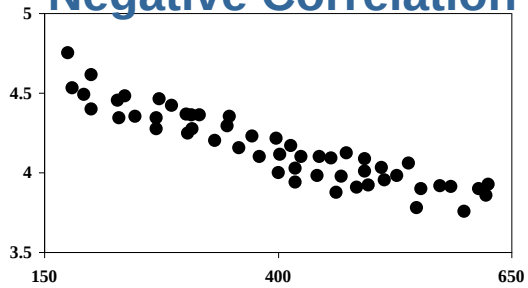
Measuring Relationships Between Variables

Positive Correlation



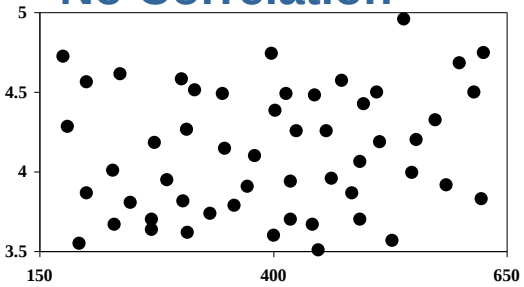
An increase in y may depend upon an increase in x.

Negative Correlation



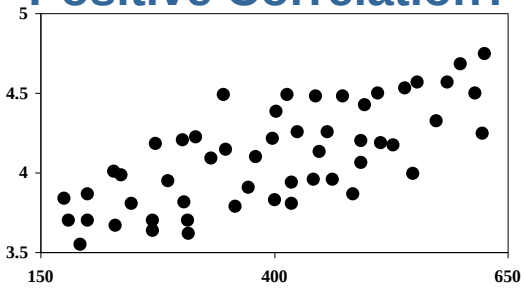
An decrease in y may depend upon an increase in x.

No Correlation



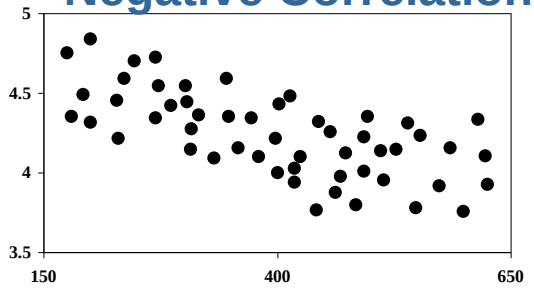
There is no demonstrated connection between x and y.

Positive Correlation?



If X is increased, y may also increase.

Negative Correlation?



If X is increased, y may decrease.

Non-Linear Correlations?

Example Scatter Plot from Tian Text

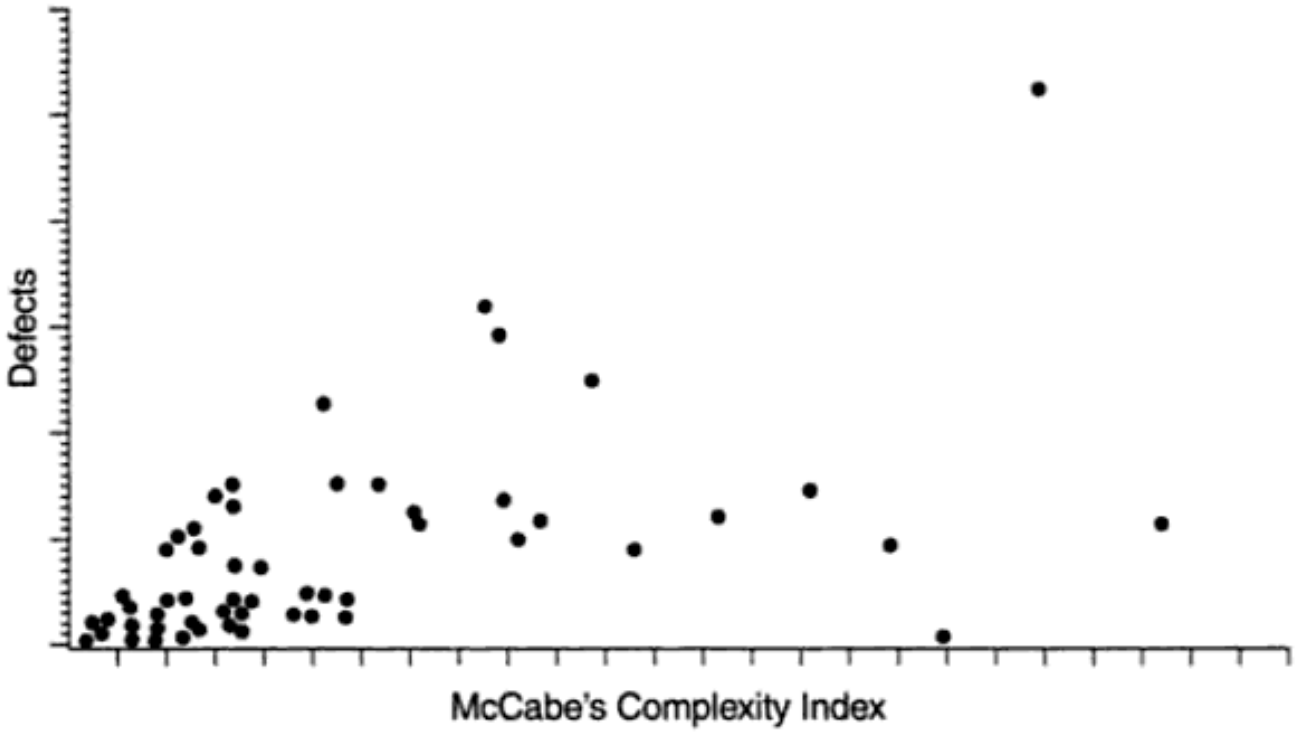


FIGURE 5.9
Scatter Diagram of Program Complexity and Defect Level

Example Scatter Plot from Tian Text

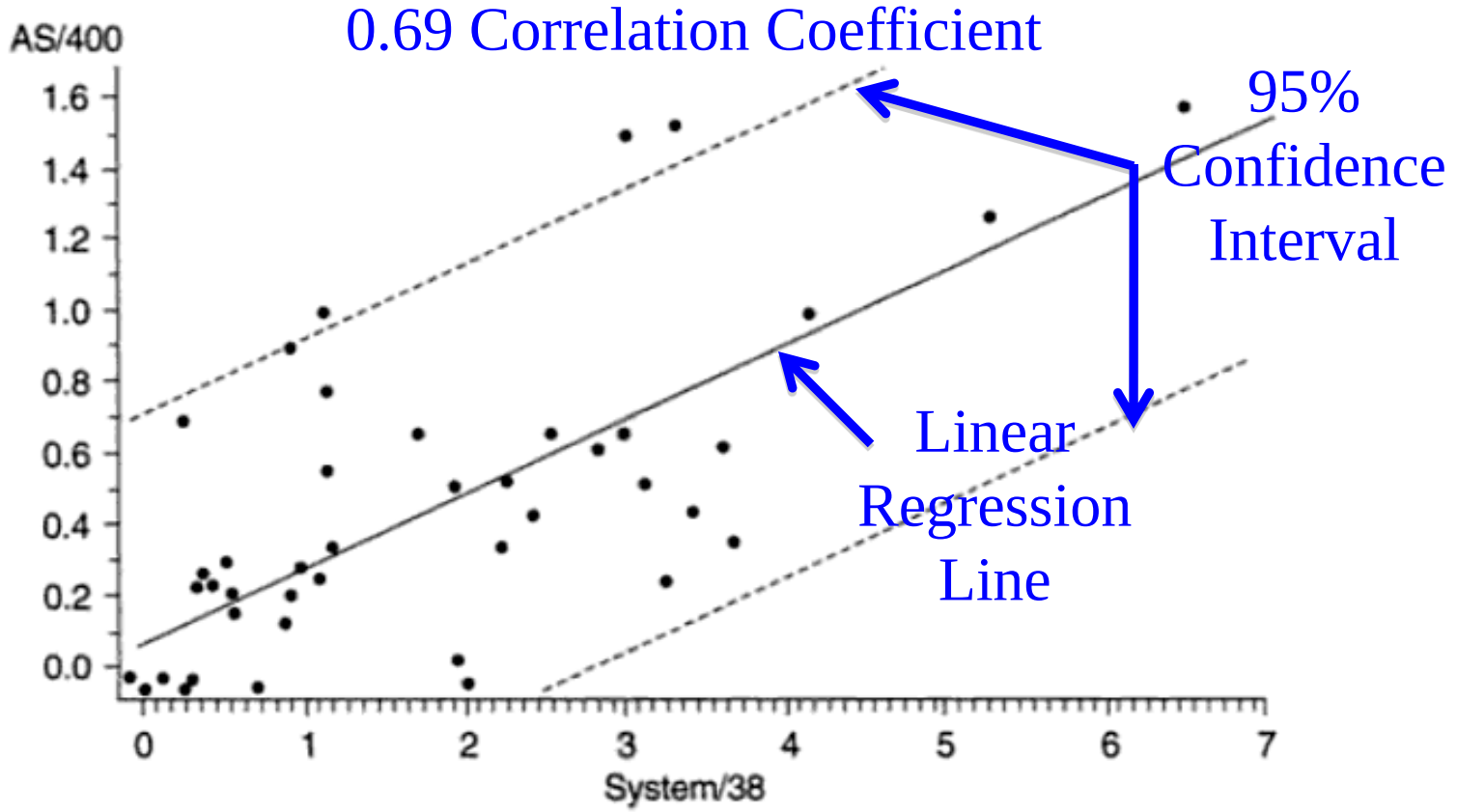


FIGURE 5.10
Correlation of Defect Rates of Reused Components Between Two Platforms

Example Scatter Plot from Tian Text

- Classify the scatter plot according to medians of component defect rate
  - Apply different analysis and improvement strategies to different quadrants

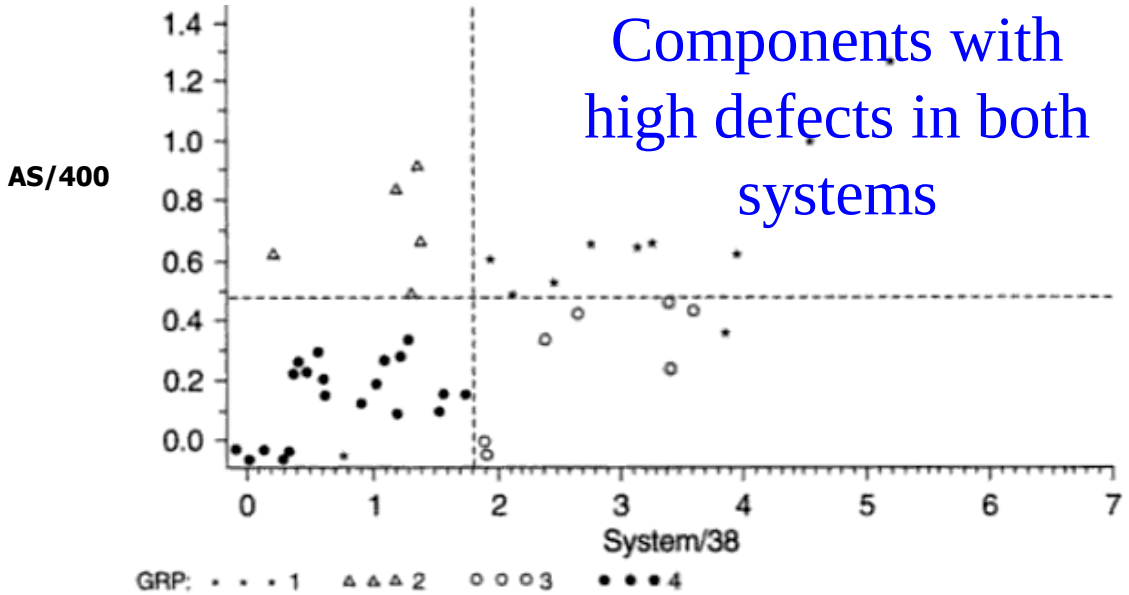
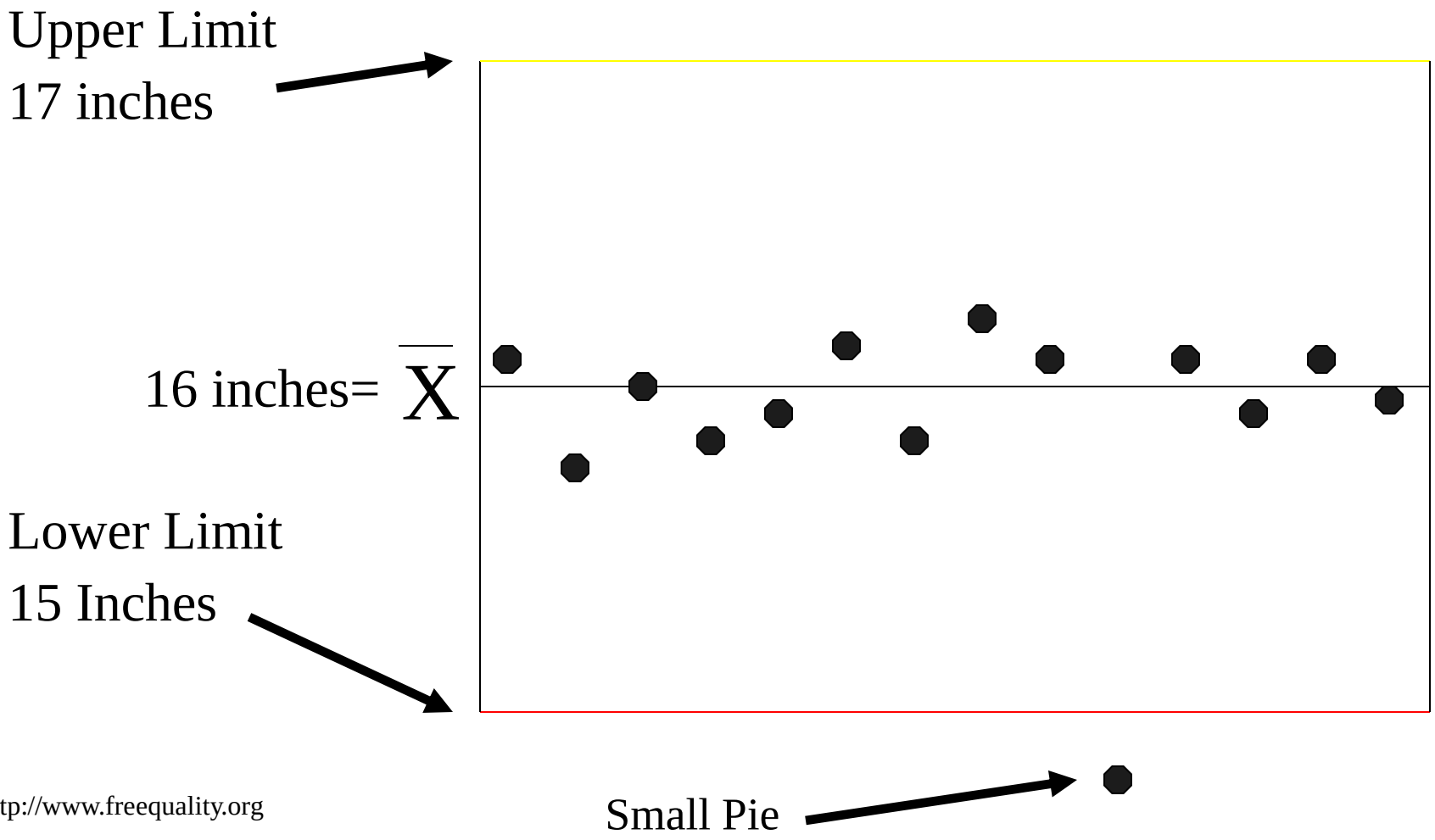


FIGURE 5.11
Grouping of Reused Components Based on Defect Rate Relationship

Control Charts

- Plot of a metric with control limits defined
  - Upper control limit: If value of metric exceeds this, take action
  - Lower control limit: If value goes below this, take action
  - Warning levels: If value outside this, check if all is well
- Control limits may be derived statistically or less formally (based on "reasonable" values or other impacts)
  - Formal statistical process control has formulas for deriving limits: often 3 sigma deviation from desired outcome
- Useful to flag "outlier" values, such as components with very high defect rates, projects that have parameters outside "normal levels" etc.
- Formal statistical process control not used much in software

Control Charts -- Pizza Example



From http://www.freequality.org

Conclusion

- The quality tools provide a suite of methods for quality analysis and control:
  - Histograms, run charts, control charts can identify problems
  - Fishbone is used to brainstorm possible causes
  - Scatter plots can be used to analyze whether relationships exist
  - Pareto analysis identifies which causes are most worth addressing
  - Checklists, templates, process definition and workflow automation can prevent problems