INDEPENDENT PROJECT ANALYSIS, INCORPORATED

Understanding Labor Productivity in High Wage Regions

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Labor Productivity Phase II

THE AMERICAS ◆ THE NETHERLANDS ◆ AUSTRALIA ◆ CHINA

Why Labor Productivity?

- This is the second report back on a three year IBC study of construction labor productivity
- Why worry about productivity:
  - About one-quarter of all construction cost is field labor
  - Labor is usually the largest non-material cost in a project
  - Very little is really understood about how to best measure field productivity or how to influence it
  - In developed economies of Europe and North America construction labor shortages will become more and more common as the population ages
  - In low wage countries, poor labor productivity is the primary obstacle to low cost manufacturing facilities

Goals of This Research

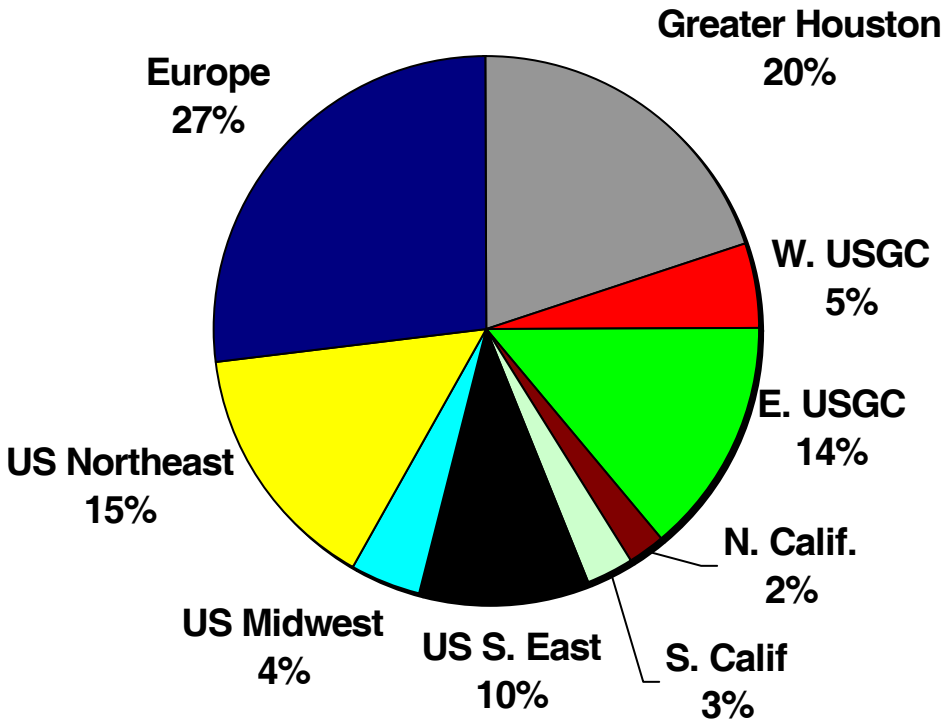
- **Phase I Goals**
  - Develop and validate a reliable approach to measuring labor cost and productivity
  - Understand the relationships between labor productivity and the project practices that IPA has traditionally gathered (FEL, etc.)
- **Phase II Goals**
  - Explore the relationship between engineering and construction execution practices and labor productivity in high wage countries
- **Phase III Goals**
  - Explore the relationship between engineering and construction execution practices and labor productivity in low wage countries

Outline

- *Measuring labor productivity*
- Review of first year's work
- More Practices and Productivity
- Productivity in Europe v. North America
- Doing something about the weather
- Conclusions

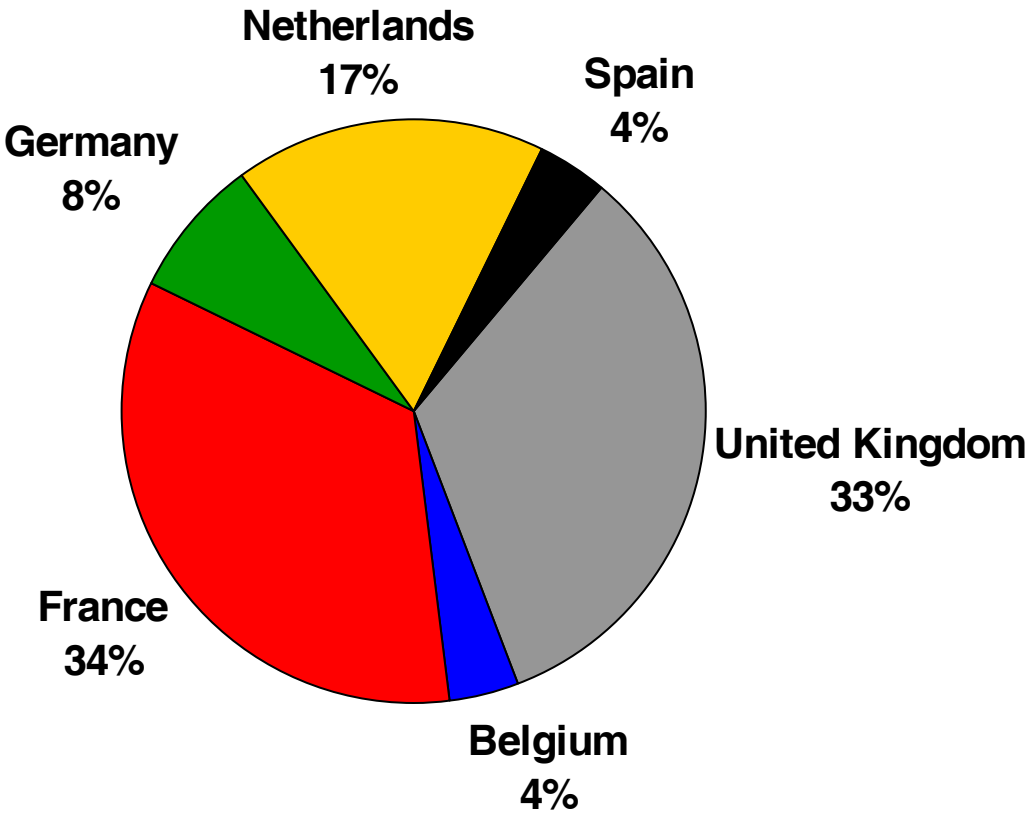
Labor Productivity Database

- 1185 projects in the United States and Europe
- 103 companies represented



European Labor Productivity Database

- 295 projects in Europe
- 35 companies represented

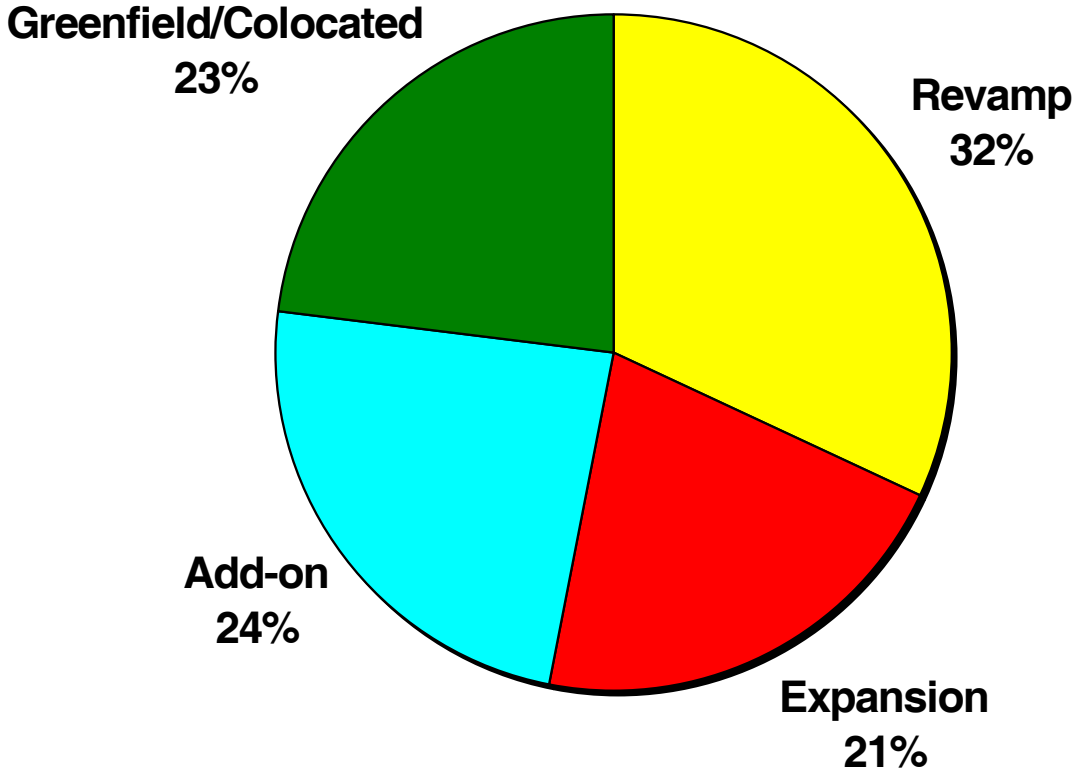


Labor Productivity Database

	Average	Median	Range
Project Size	$36.6 MM	$12 MM	$0.054 MM - $1547.07 MM
Start Year of Construction	1995	1996	1972 - 2001

1988 USD basis

Labor Productivity Database



Defining Labor Cost

- **Labor cost** is the amount of money spent on field construction, including
  - Wages
  - Benefits
  - Small tools
  - Subcontractor profits and fees
  - Overtime premiums
- Does **not** include
  - Construction equipment (e.g. cranes, bulldozers, backhoes, etc.)
  - Construction supervision
  - Field engineering

Methodology (1)

- Projects were again grouped according to process type and project type to minimize scope variations
- A base location was created in Europe
- Database was increased from 570 to 1100
- Both large and small projects were added
- Labor cost breakouts were available for all projects

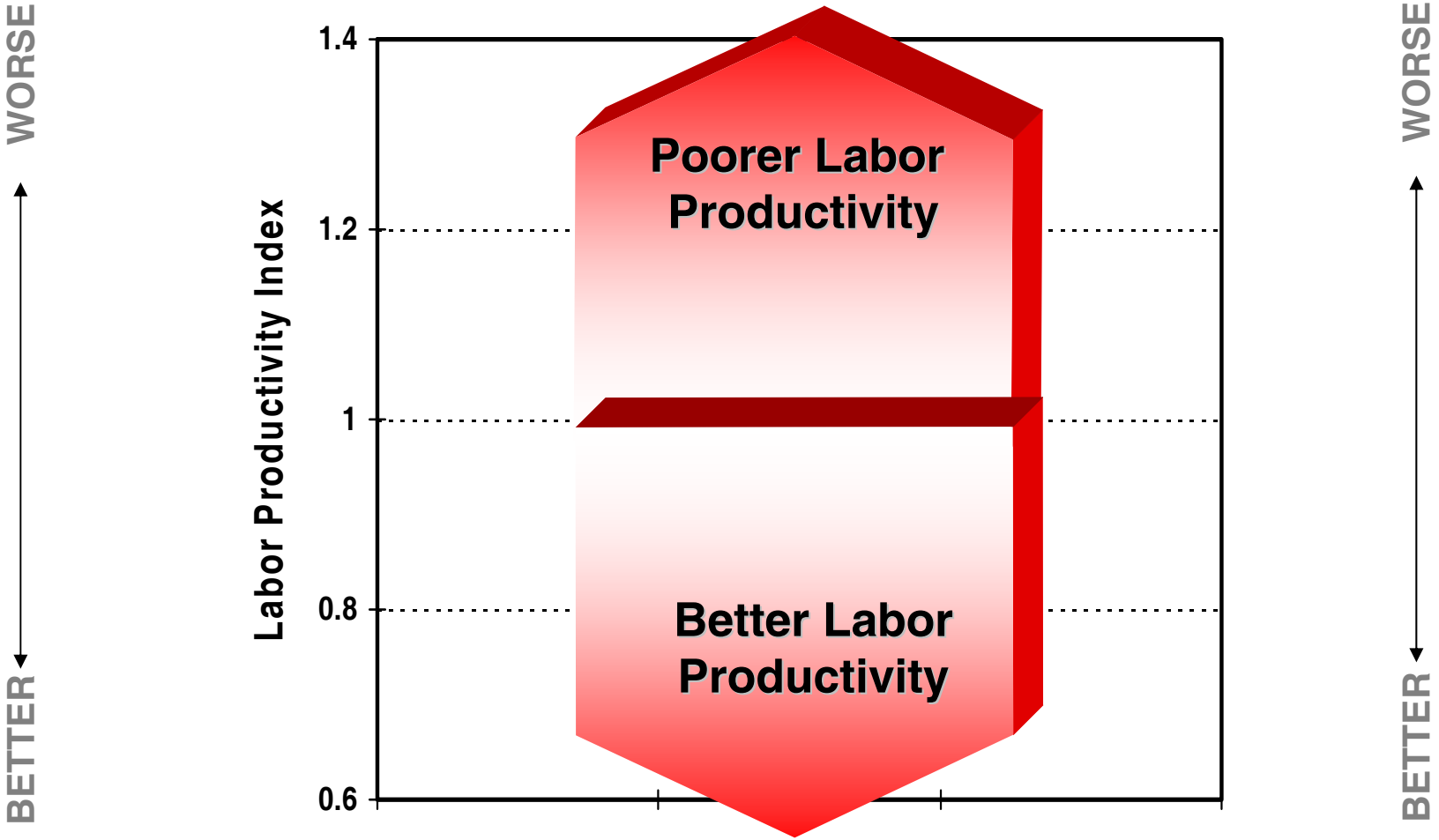
Methodology (2)

- Each group provides a good like-for-like field work to be performed
- Modular projects were excluded to minimize error
- Each group has good dispersal of projects geographically
- Each group has a good sample of projects in Greater Houston to provide a US Gulf Coast anchor
- As the methodology develops, other “anchors” will be developed and become interchangeable
  - Rotterdam has been added this year
  - Singapore and São Paulo will be added next year

Methodology (3)

- Effective Labor Cost Index compares the amount of labor required within each group; groups are then aggregated
  - The Labor Cost Index measures the relative amount of money a project spent on field labor
  - Greater Houston is set equal to 1.0
- The Labor Productivity Index is created by adjusting the all-in wages to the same US dollar basis
  - The Labor Productivity Index measures the comparative number of labor hours that like scope required to complete

Labor Productivity Index



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- More Practices and Productivity
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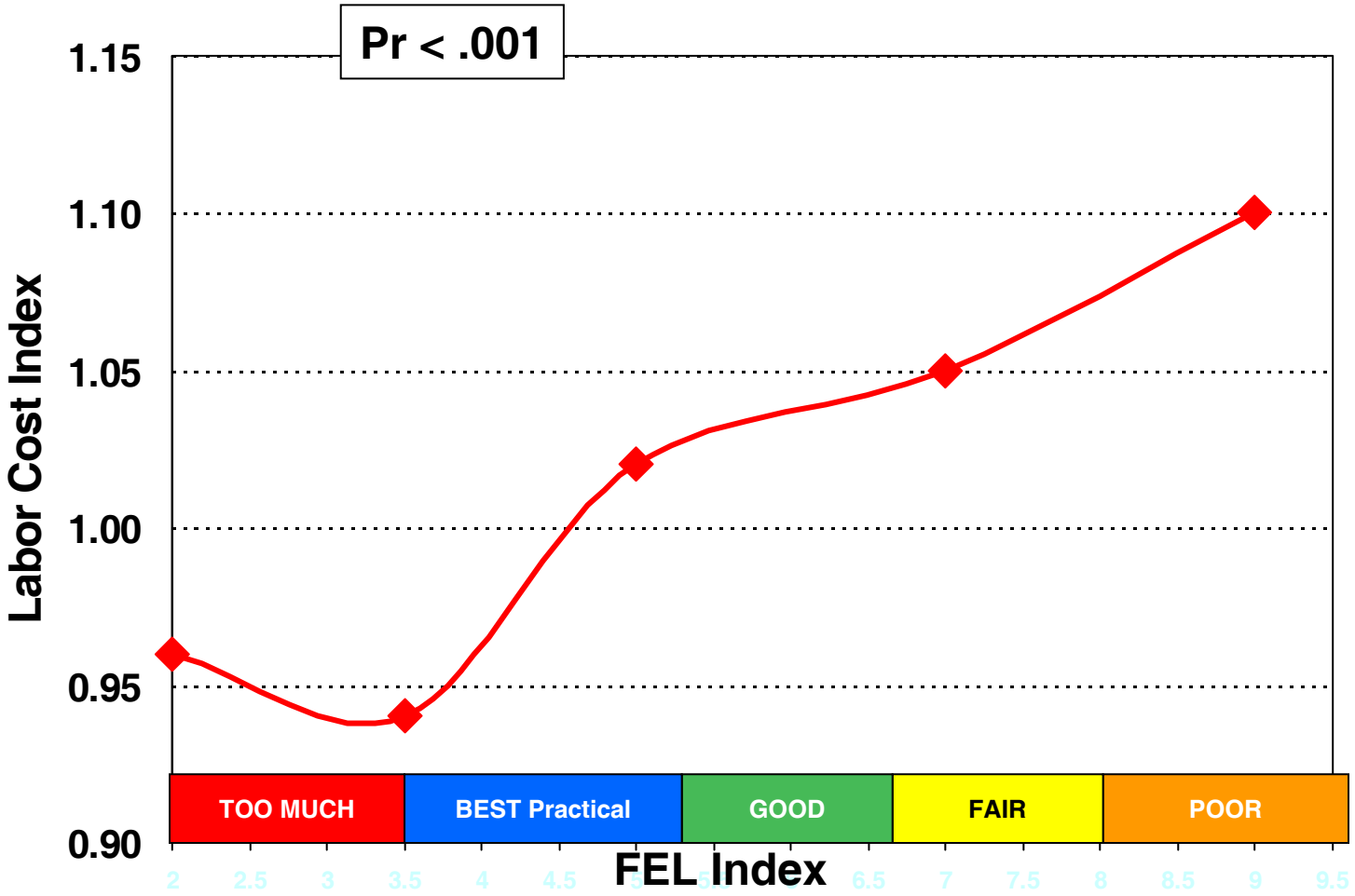
Primary Conclusions

- There is little variation in *effective labor cost* from region to region
  - Standard error across regions is only 7 percent
  - Corrected by company standard error is 4 percent
- There is more variation in productivity from region to region
  - Standard error is 10 percent
  - 7 percent corrected by company
- Variation in productivity is dampening the variation in effective labor cost
- Labor unions on average supply considerably more productive labor in the United States

Conclusions About Regional Variation

- Very little true region-to-region variation in cost, especially in the same general labor market
  - Contradicts perceptions of many company estimators
  - Because they extrapolate their company's experiences or listen to contractors' whining
  - Accords better with economic theory
- Average productivity differences probably driven by differential skill levels
- Much of the regional variation is really variation by company

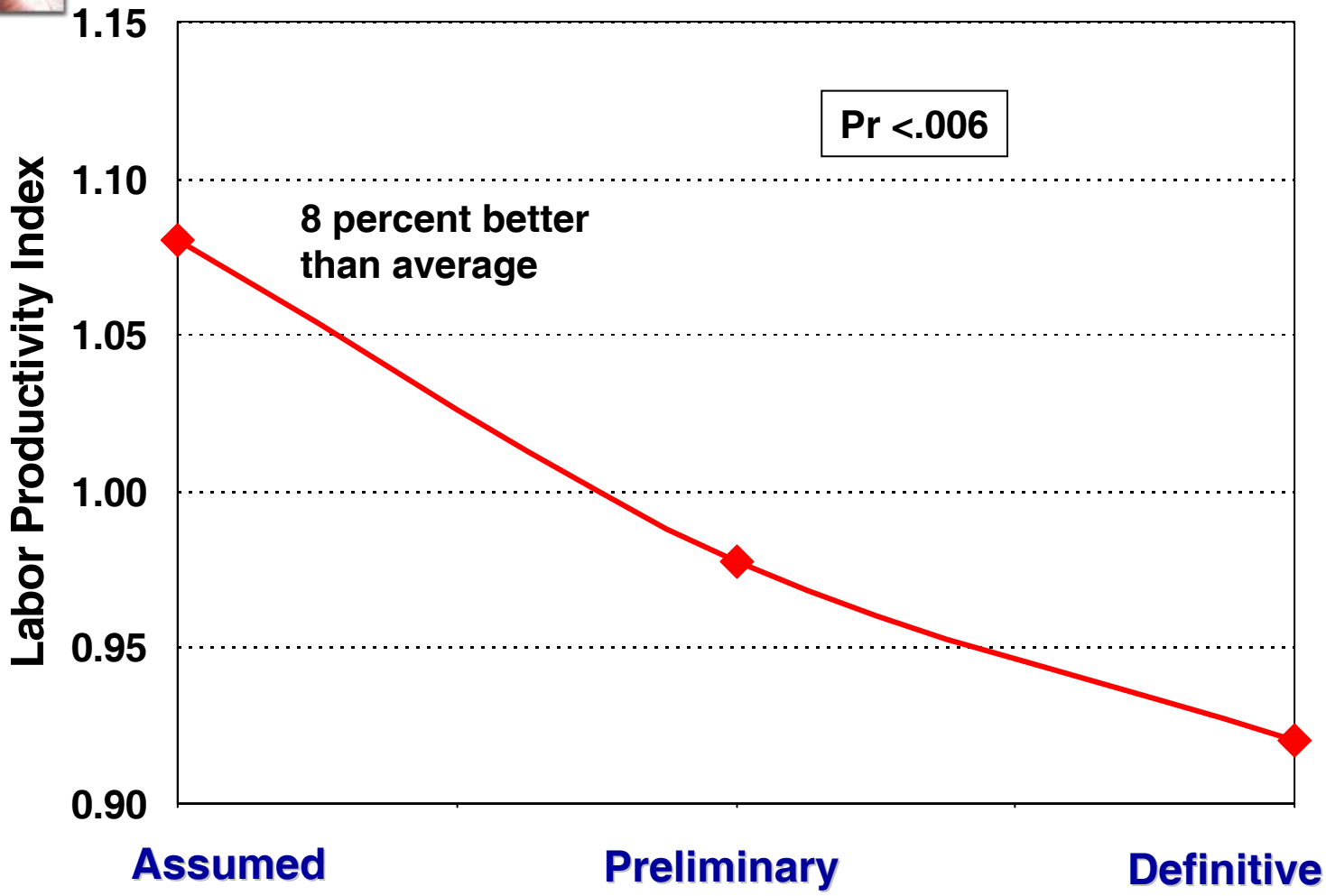
FEL Drives Labor Cost Index



FEL Drives Labor Productivity

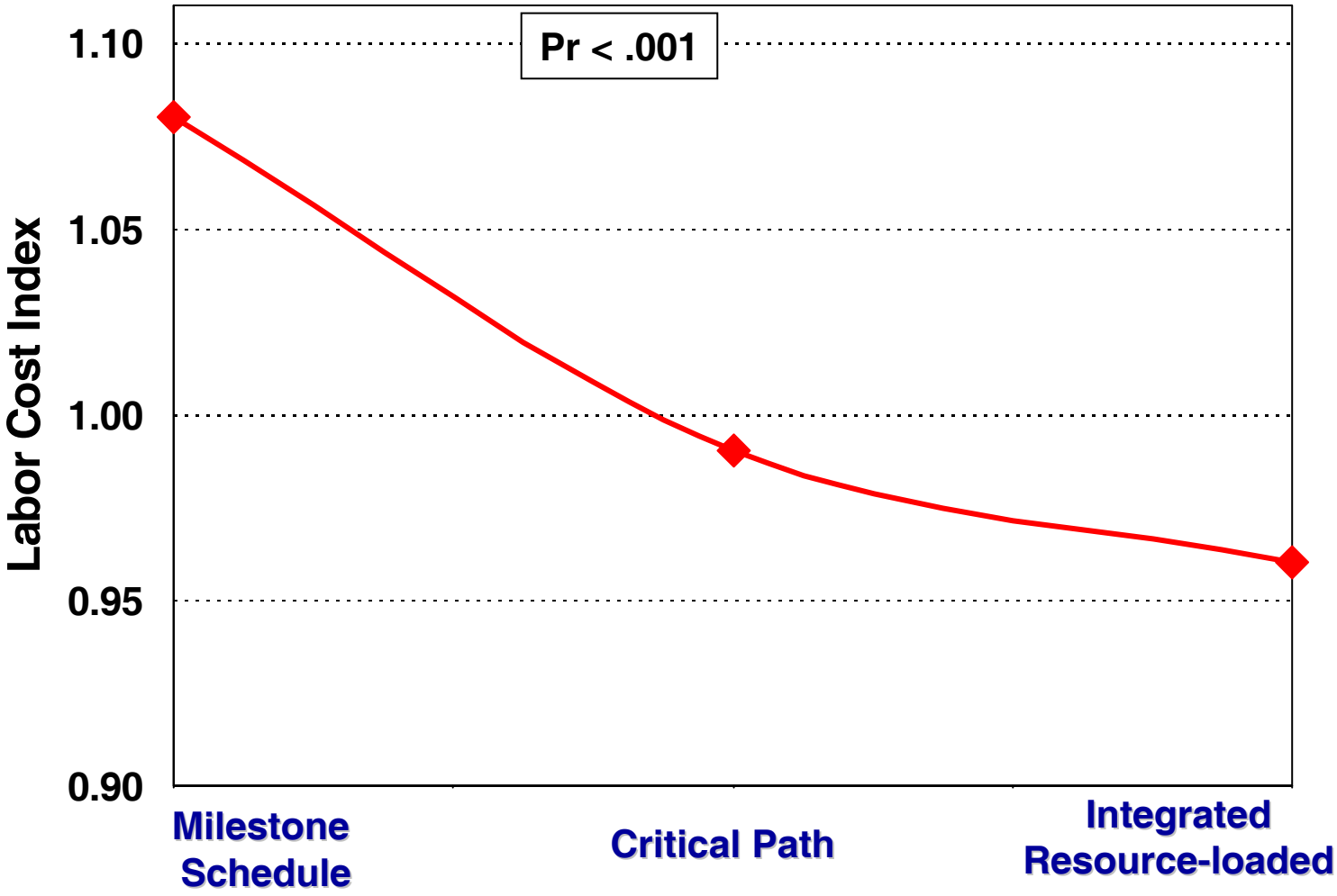
- Significant components are:
  - Definition of soils
  - Definition of health and safety
  - Engineering status
- By far the most important FEL Component for Productivity is **Execution Planning**

Execution Planning Drives Productivity

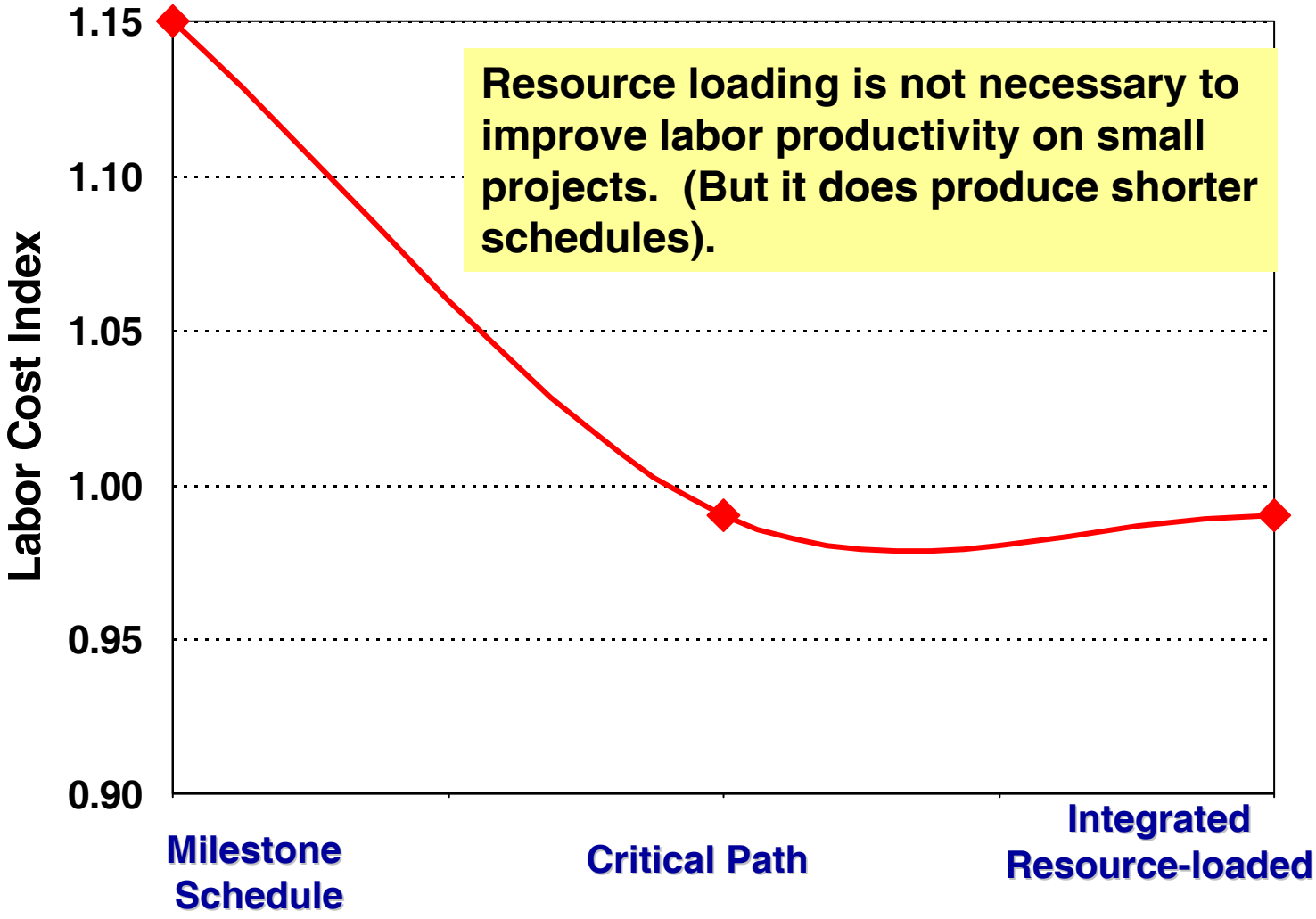


The Effects of Detailed Scheduling

All Projects



The Effects of Detailed Scheduling
Small Projects



Labor Productivity and the VIPs

- Value engineering + 5 percent
- Predictive maintenance + 7 percent
- Design to Capacity + 9 percent
- 3D CAD + 7 percent (and up)

- No other relationships with VIPs, including no relationship with Constructability Reviews!

Outline

- Measuring labor productivity
- Review of first year's work
- *More Practices and Productivity*
  - *contracting*
  - *teams*
  - *planning and control*
  - *construction supervision*
  - *use of overtime*
- Productivity in Europe v. North America
- Doing something about the weather
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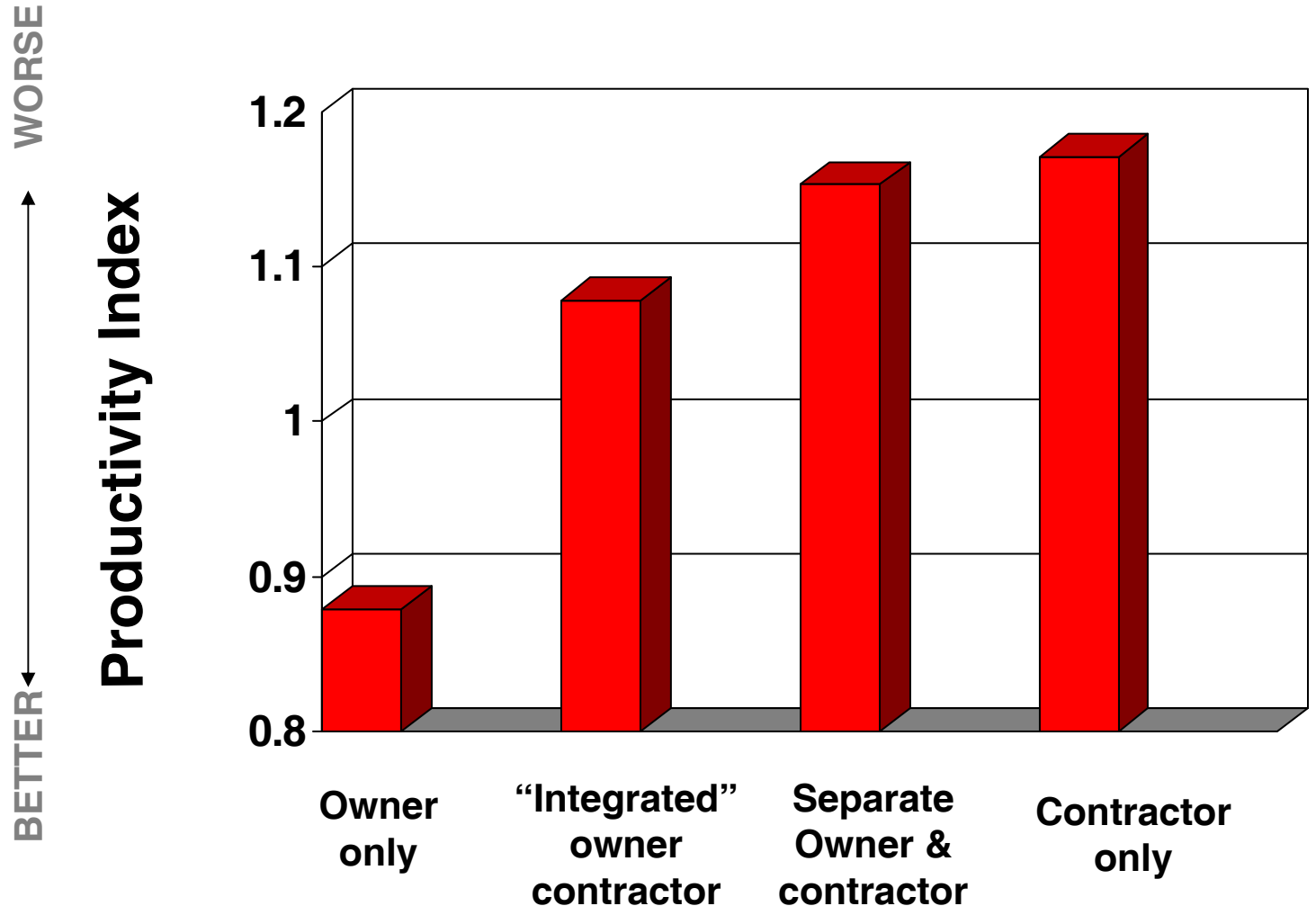
Contracting and Productivity

- Union jobs are almost 17 percent more productive on average than open/merit shop in the USA
- Union jobs averaged a labor cost index of 0.998 versus 1.08 for non-union construction outside the USGC
- Mixed union/non-union jobs are slightly **less** (Poorer) productive than open shop and much less productive than union jobs
- Subcontractor supplied labor is 13 percent more productive on average than direct-hire

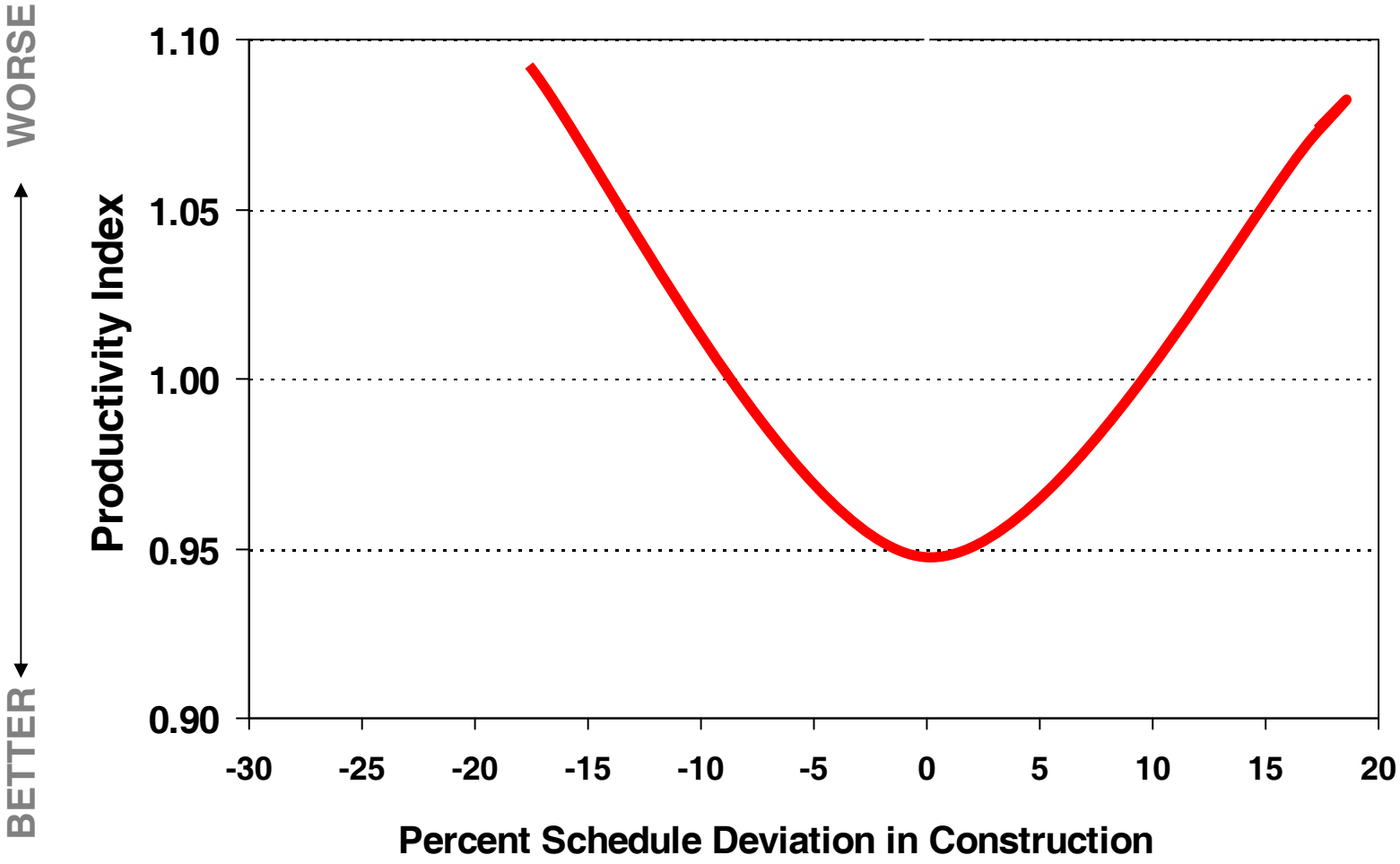
Teams and Productivity

- Integrated team projects have 6 percent more productive field labor
  - environmental specialist involvement is important
  - health & safety specialist is important
- Using an owner scheduling engineer, starting in FEL, is associated with 7 percent better productivity

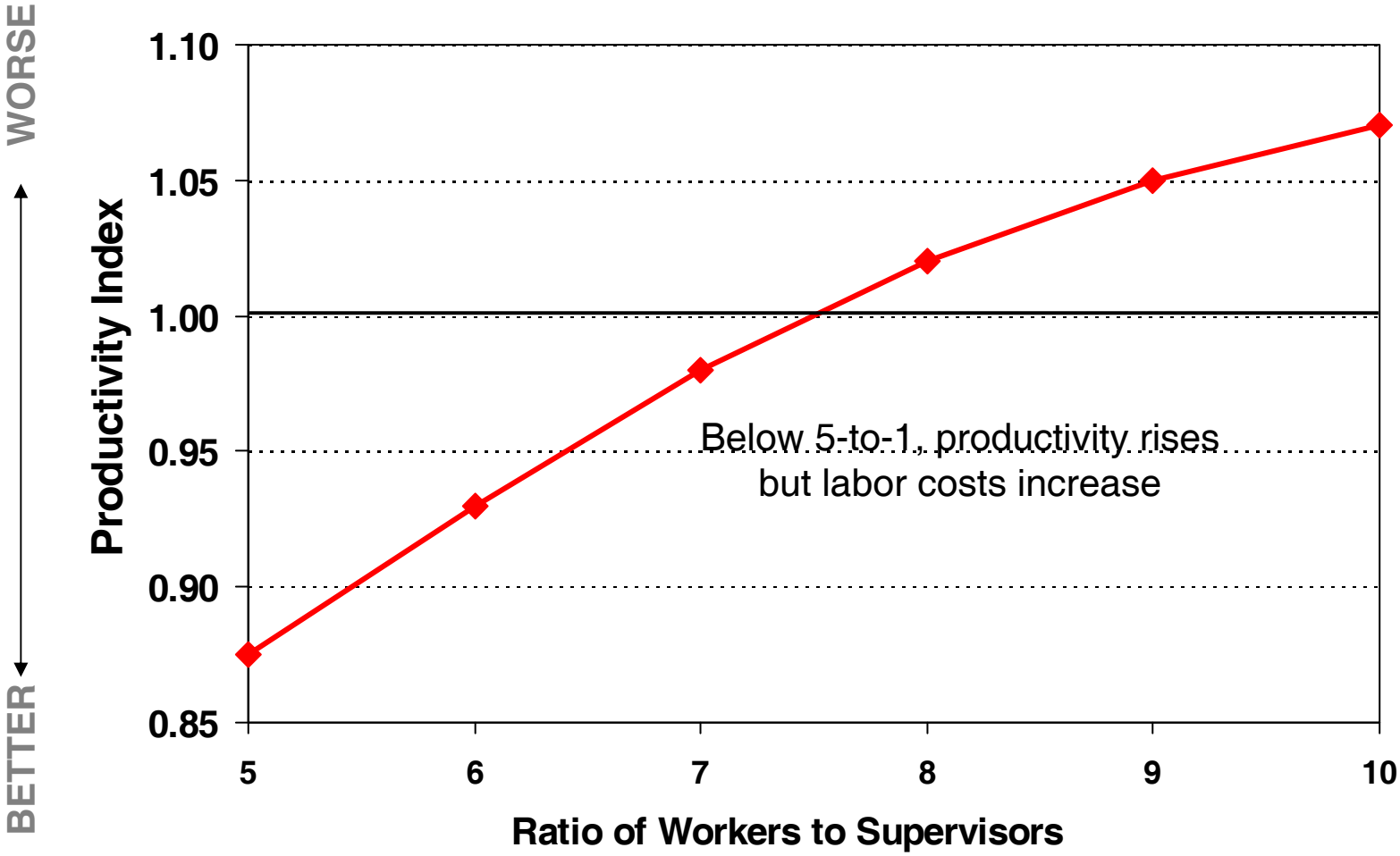
Whose Cost/Schedule Control Plan?



Any Deviation from Construction Plan Drives Poor Productivity



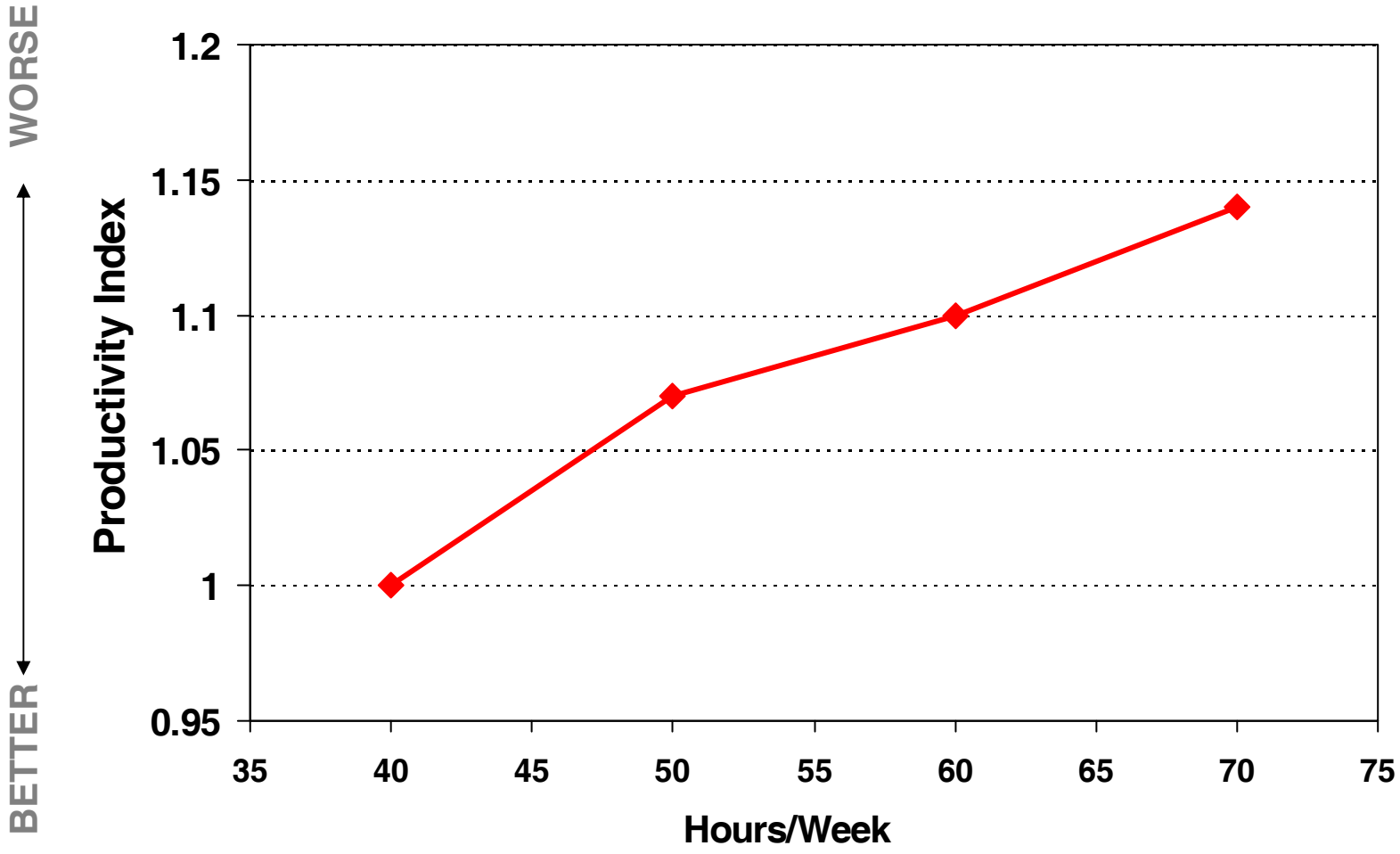
Added Supervision Improves Productivity



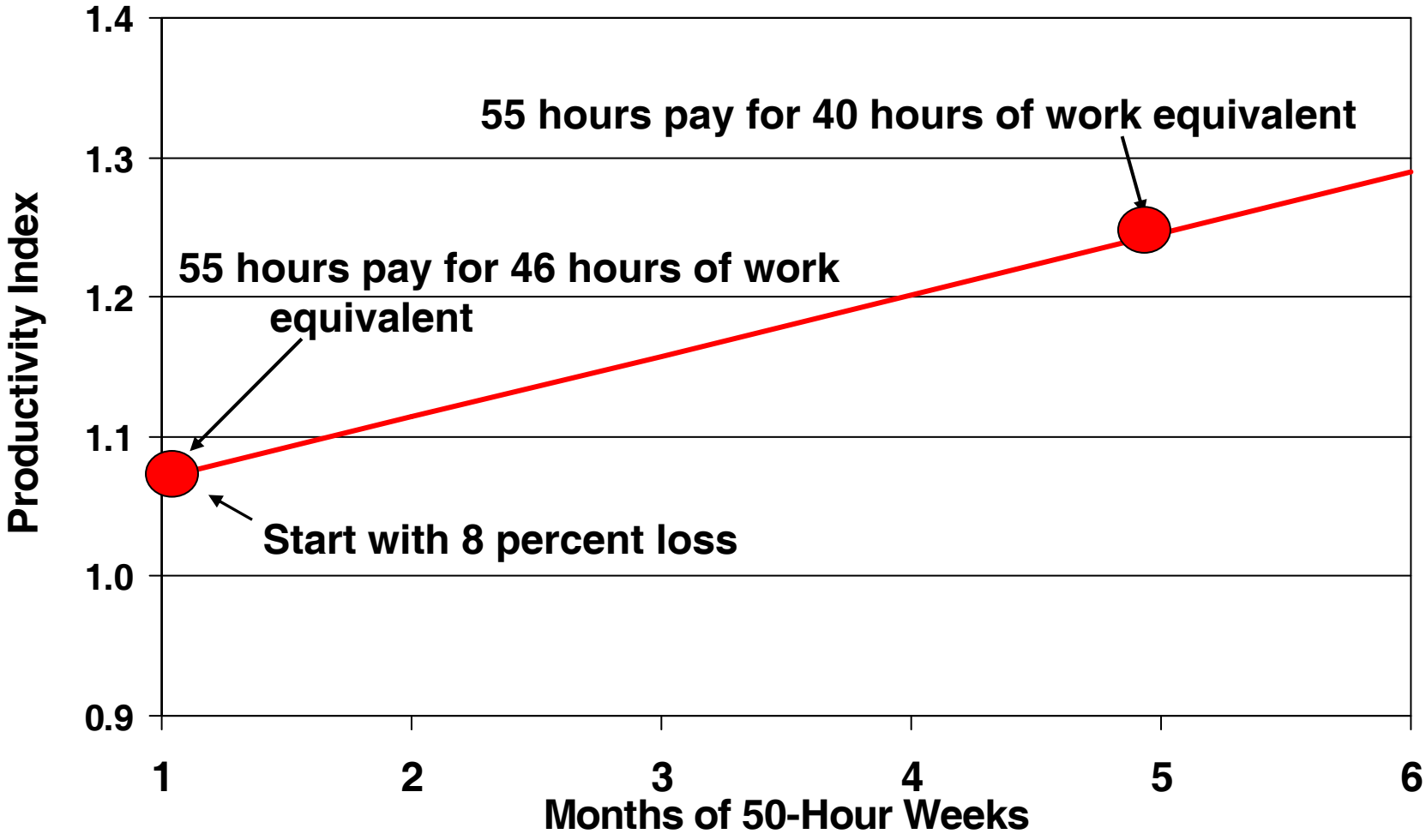
The Effect of Overtime on Productivity

- The use of overtime is the most common way to recover slipped schedules and accelerate projects that are schedule-driven
- Overtime is also sometimes used to attract labor when shortages occur
- Overtime was used on over a third of North American projects and a quarter of European projects
- The use of overtime is increasing
- The adverse effect of overtime on productivity is accepted as fact despite the dearth of empirical analysis, especially for the process industries

Productivity Declines as Work Week Increases



The Effect of Extended 50 Hour Weeks



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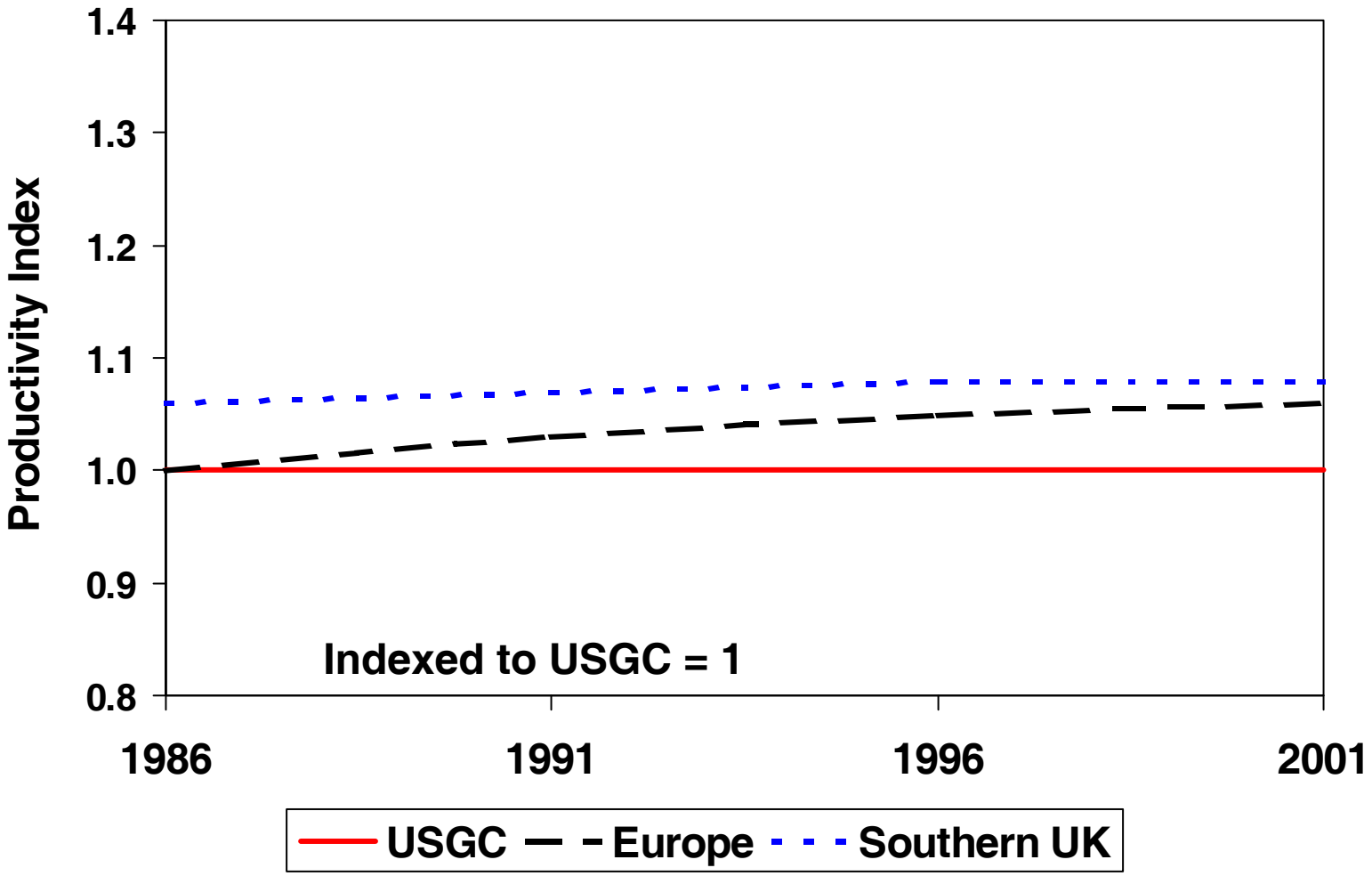
Europe v. North America

- Differences are generally not large
- The relationships between practices and productivity results are virtually identical
  - same effect of FEL
  - same VIPs, etc.
- One interesting difference:
  - Environmentally-driven projects on the USGC are characterized by poor labor productivity (+12 percent)
  - Such projects in Europe are characterized by excellent productivity

Productivity Over Time



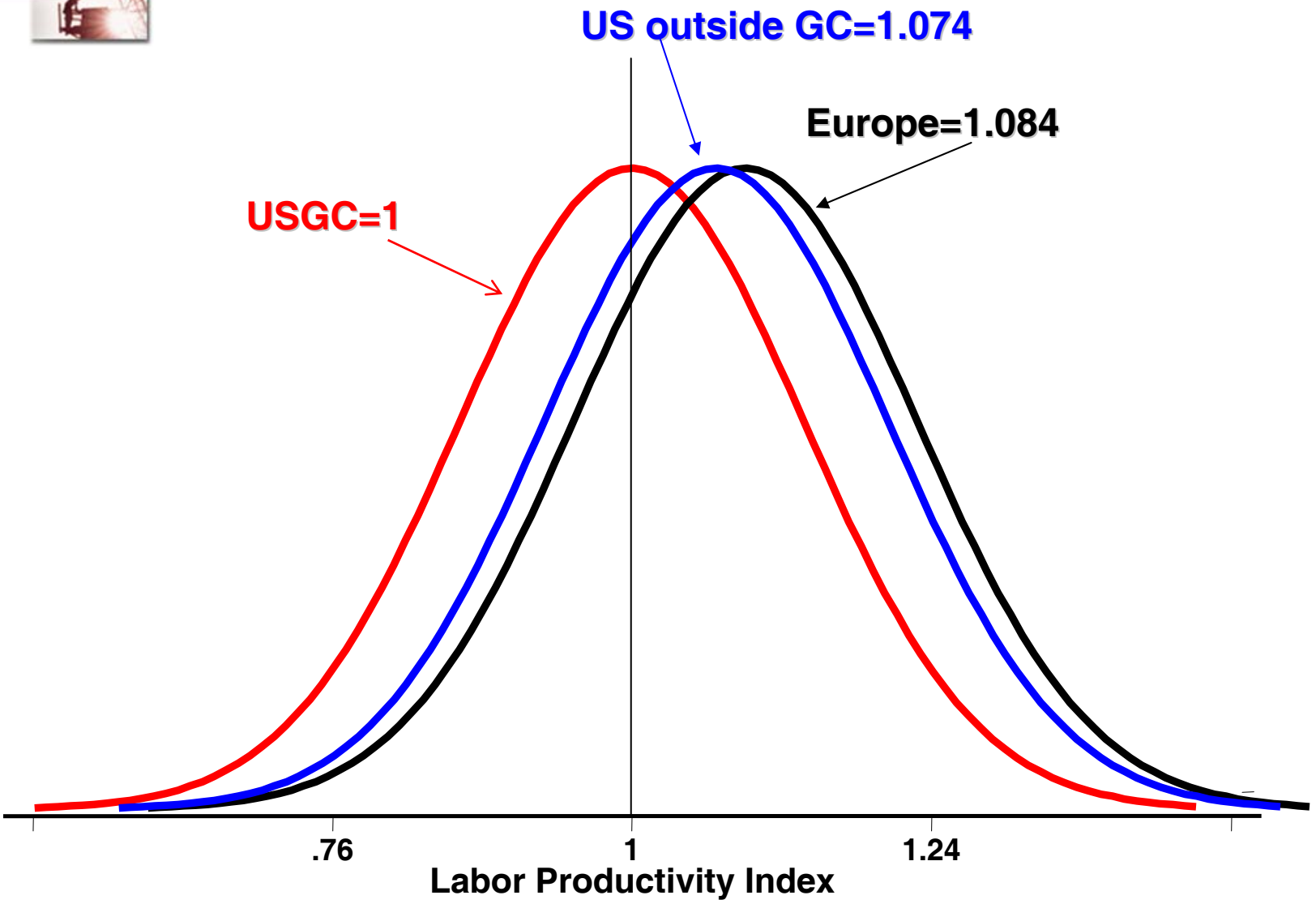
Regional Variation Within Europe

Region	Effective Labor Cost	Relative Productivity
Northern UK	1.04	1.10+
Southern UK	1.05	1.12
Belgium	0.97	0.97+
France	1.12	1.13
West Germany	1.15	1.10++
East Germany	1.12	1.15++
Netherlands	1.06	0.96
Spain	0.89	1.16

At 1 March 2002 exchange rates

+ Result is driven by a performance of single company
++One company is influential

Very Little Difference in Labor Productivity



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Why Worry About the Weather?

- The weather is a significant risk factor for many projects
- The weather is an important estimating issue between owners and contractors and is sometimes used by contractors to “fatten” estimates on reimbursable or negotiated lump-sum contracts
- Therefore, establishing some quantitative data around the effects of specific weather on productivity should be useful

Weather data

- The US National Oceanographic and Atmospheric Administration (NOAA) keeps very detailed records of weather at most construction locations in the USA
- We purchased daily weather information in electronic form for the construction periods of approximately 50 percent US projects in our productivity database
- We then matched weather results to productivity

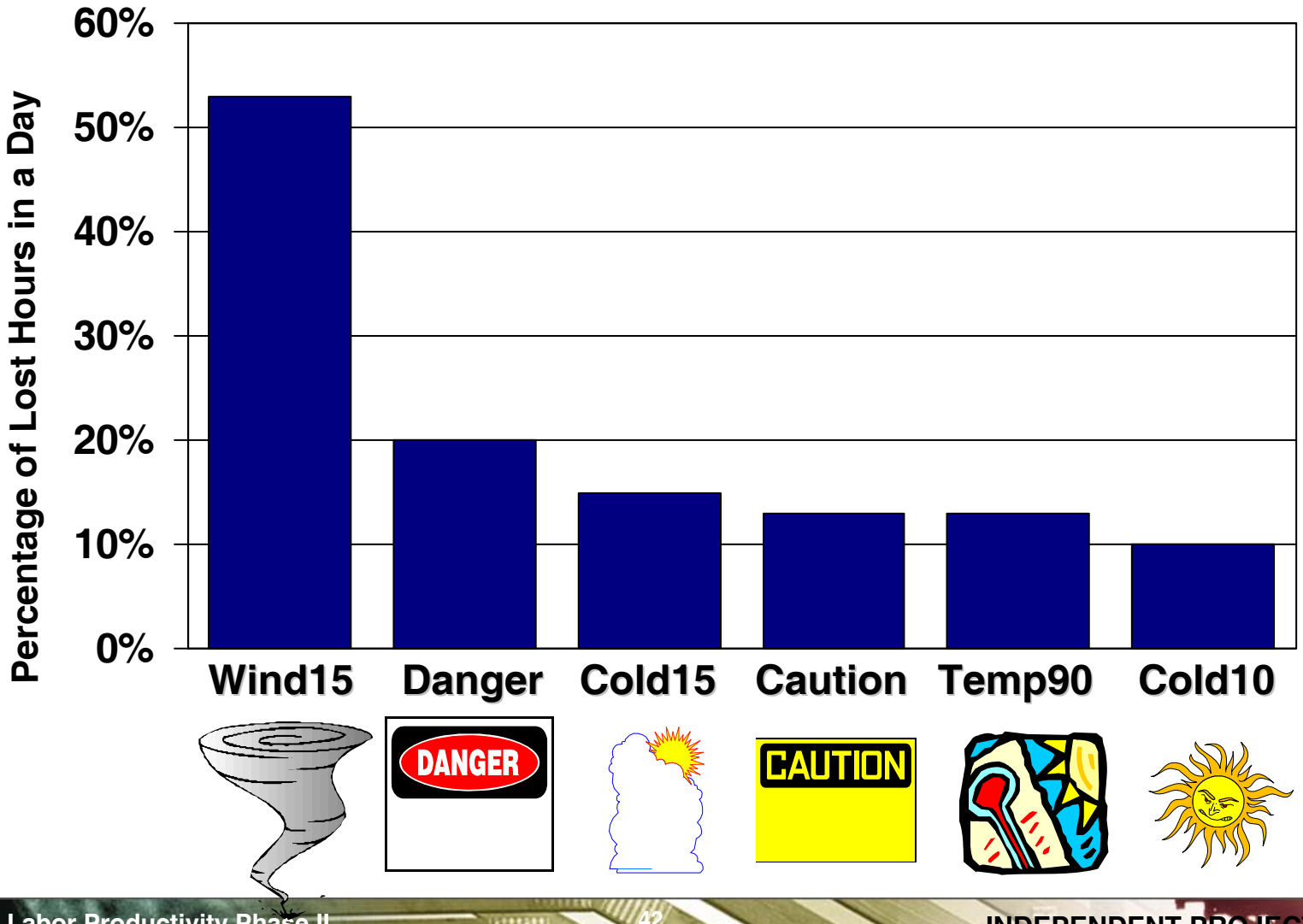
Weather Variables

- **Temperature Variables**
  - ***temp90*** **- Percent of construction days with the daily high temperature above 90 degrees Fahrenheit (32 degrees C)**
  - ***cold****xx* **- Percent of construction days with the "cooling degree days" measure greater than 10, 15, 20, or 25. Cooling degree days are measured as each degree of temperature of the daily mean above 65 degrees F (18 degrees C).**
  - ***Heat****xx* **- Percent of construction days with the "heating degree days" measure greater than 10, 15, 20, or 25. Heating degree days are measured as each degree of temperature of the daily mean below 65 degrees Fahrenheit.**
- **Precipitation Variables**
  - ***snow*** **- Percent of construction days with 1/2 inch or more of daily snowfall**

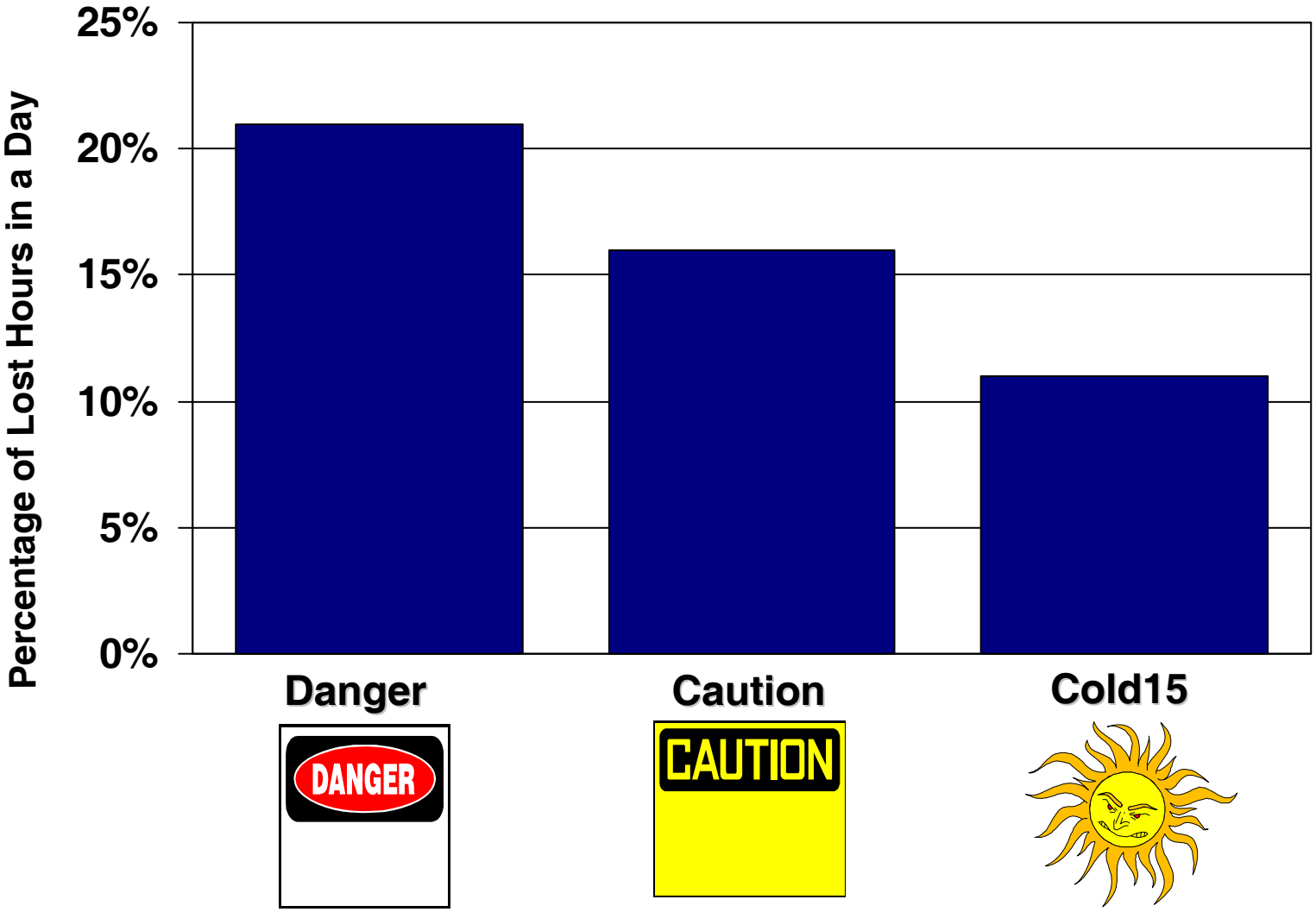
Weather Variables (cont.)

- **Wind**
  - ***windxx*** **- Percent of construction days with resultant wind speed greater than 15, 20, or 25 miles per hour. Resultant wind speed is calculated as the vector sum of the wind's speed divided by the number of observations.**
- **Discomfort**
  - ***Caution*** **- Percent of construction days where combination of heat and humidity qualified as a "caution" condition by the National Weather Service**
  - ***Danger*** **- Percent of construction days where combination of heat and humidity qualified as a "Danger" condition by the National Weather Service**

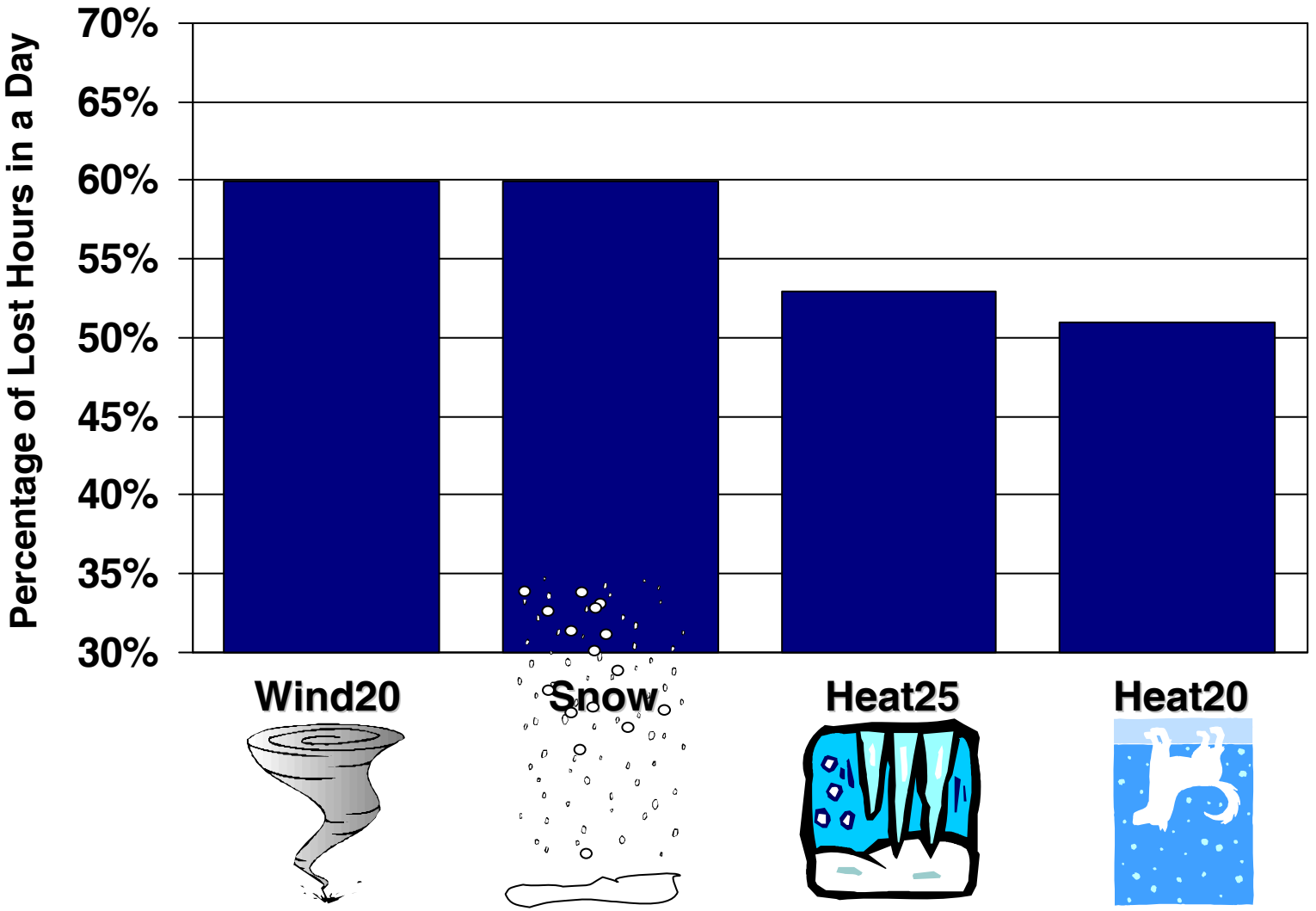
General Effects of Weather on Productivity



Weather Effects in Warmer Regions



Weather Effects in Northern US



Weather Conclusions

- High winds are most destructive of labor productivity
- The effects of rain are too small to detect except for projects that involve large amounts of difficult welding, e.g. hydroprocessing
- The effects of weather are quantifiable
- Data necessary to find averages are generally available
- Owners might consider taking weather risks whenever the contractor's predicted effects are higher than average

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Conclusions

- Overall project-to-project variation in labor productivity is 24 percent on a single standard deviation
- Even within highly homogeneous projects in the same region, the variation is about 15 percent
- This means there is a substantial gain available in improved labor productivity
- Good labor productivity does more than reduce cost
  - Improves schedule
  - Improves quality

Keys to Better Productivity

- Detailed execution planning is the single most important driver of better field productivity
- Execution planning has been progressively outsourced to contractors
- But the data are clear: owner execution planning and control are central to securing good labor productivity
- The principal role of the engineering contractor is to provide timely, high-quality engineering documents to construction; it is not to take the place of the owner in the execution planning process

Path Forward -- Phase III

- Work will continue on the collection of more detailed practices in the field that may affect productivity
- Regional focus for IBC 2003 will be Latin America and Asia
- Main emphasis will be on low-wage, generally lower skilled labor situations in which major cost swings can be achieved