Performance Effects of Measurement and Analysis: Project, Product and High Maturity

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Software Engineering Institute | Carnegie Mellon

Today's Talk

Scope of the presentation

More results from the 2009 high maturity survey in the SEI's series of measurement & analysis state-of-the-practice sample surveys

- Surveys of appraised organizations in 2008 & high maturity lead appraisers (HMLAs) in 2009
  - Great deal of consistency in replies & statistical relationships
  - Based on perspectives of two groups that are often thought to be quite different
- Focus here today on results linking process performance modeling to success in achieving organizations' appraised high maturity level goals

Summary, lessons learned & next steps

Why is This Work Important?

Confusion still exists about what is necessary to meet the high maturity goals of CMMI based process improvement

- & the value of improving measurement capability often isn't appreciated in lower maturity organizations

We need more & better measured evidence about the quality & performance outcomes that are possible with CMMI-based process improvement

- Especially in these times of limited resources & increasing skepticism
- Without such evidence continued support for CMMI is at increasing risk

The Wider Body of Work

In depth studies

- SEI's series of workshops on measurement & analysis activities in high maturity organizations
  - In-depth presentations by leaders in the field: 5 workshops over 3 years
  - Focused initially on value added by CMMI-based process performance modeling
  - Detailed discussions of modeling methods & results
  - Additional collaboration within ***& across*** organizations
  - (References & URLs are at the end of this presentation)
- Similar work ongoing through SEI Partner Network working group of leading HMLAs

Wider publication of results

Additional workshops & colloquia (TBD)

Other ideas?

- Let's talk later!

Sample Surveys

Measurement & analysis state-of-the-practice series since 2006

- & occasionally since 1990
- A basis for more broadly based comparisons across programs & organizations
- Focus on value added by CMMI process performance modeling since 2007
  - As it varies with the extent of use & understanding of PPMs
  - Along with other aspects of measurement & analytical practices
  - As well as organizational resources & management support
  - 2009 response rate: 55%

A little about validity & generalizability of sample surveys…

- Candid replies recognizing:
  ... (Particularly seen in open-ended text responses) ...
  - Weak points & need for improvement
  - Backsliding over time
  - Failure to achieve appraisal goals
- Consistent covariation with performance outcomes
  - Business value
  - Achieved maturity levels

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Summary, lessons learned & next steps

How do the Samples differ?

To review from last year...

2008: Sponsors of organizations appraised at maturity level 4 & 5

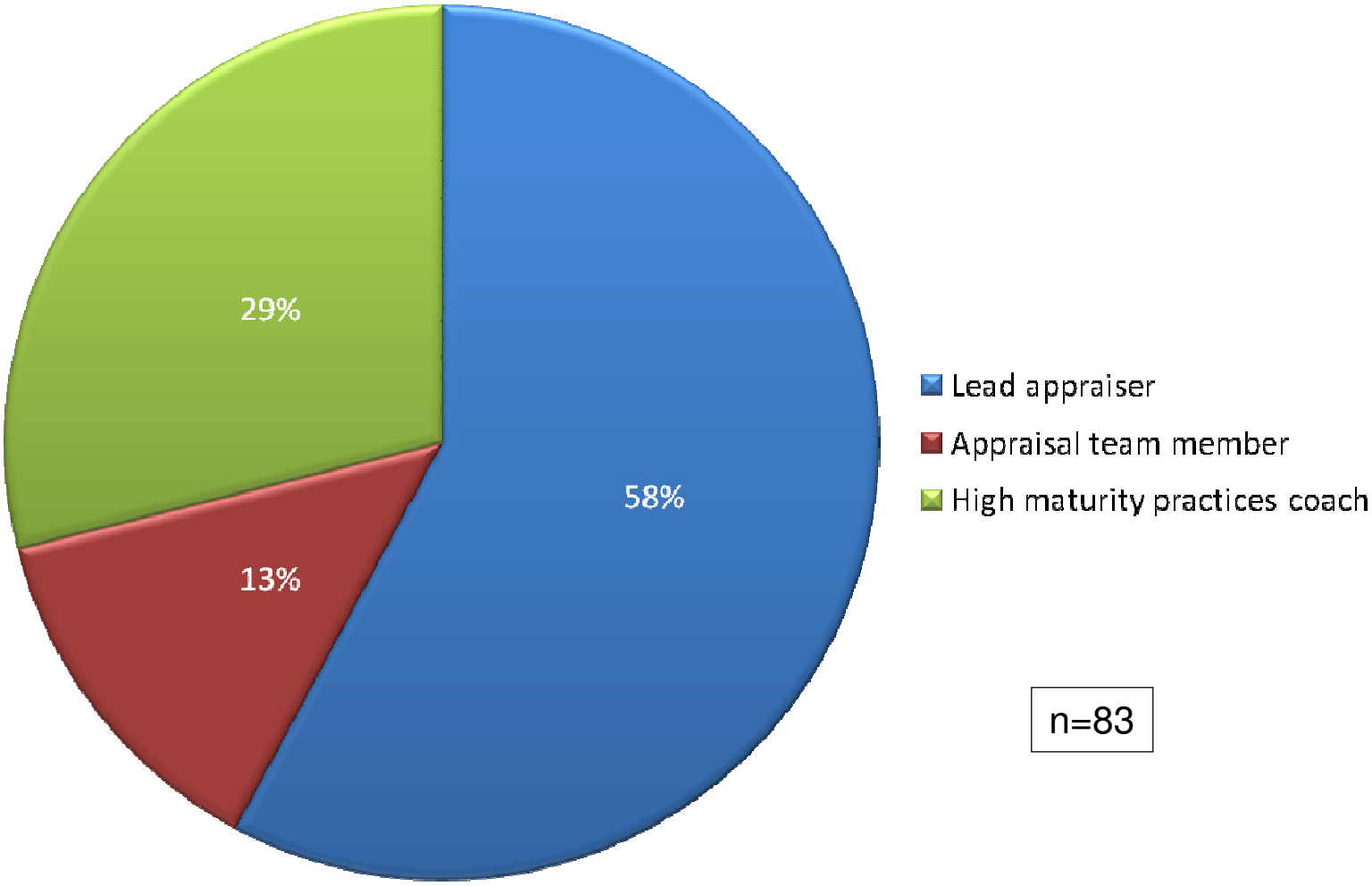
2009: HMLAs asked to answer from perspective of organizational units

- With which they worked & were most recently appraised for CMMI-based high maturity status
- As lead appraisers, appraisal team members, or in a coaching capacity

Still a relatively small number of HMLAs with direct experience at time of 2009 survey

- Realized sample would include HMLA replies about organizations that did not achieve appraised high maturity goals
- Useful to better understand HMLA reports about use & value added by analytical approaches & methods used for process performance modeling among organizations seeking appraised high maturity status

HMLA Role



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The Survey Data Do *Not* Speak for Themselves

Perceptions & expectations often differ among survey respondents

- & they probably do by maturity level
- e.g., standards about how much is enough to justify a positive answer

We're not claiming cause & effect

- It's statistical association at one point in time
- Cause & effect often are recursively reciprocal over time
- ***Keep this in mind as we review the evidence!***

Results described more fully in two SEI technical reports

- CMU/SEI-2008-TR-024
- CMU/SEI-2010-TR-022
- (References & URLs are at the end of this presentation)

Comparable Organization Scope in Both Years

Similar organizational context in the 2008 and 2009 high maturity surveys

- Sector (commercial, contracted new development, in-house or proprietary development or maintenance, defense contractors, other government contractors, DoD or military organizations)
- Focus (product or system development, maintenance or sustainment, acquisition, service provision)
- Engineering discipline (software, systems, hardware, design, test)
- Number of FTE software, hardware or systems engineering employees

They do differ somewhat by country

- More from China & relatively fewer from India
- Possibly since the 2009 engagements are more recent

Synopsis & Implications

As noted last year: Overall results from HMLAs in 2009 are consistent with reports from HM appraisal sponsors in the 2008 survey

Considerable understanding & use of process performance models (PPMs) is evident in both surveys

Judgments about value added by process performance modeling also vary predictably along with variation in:

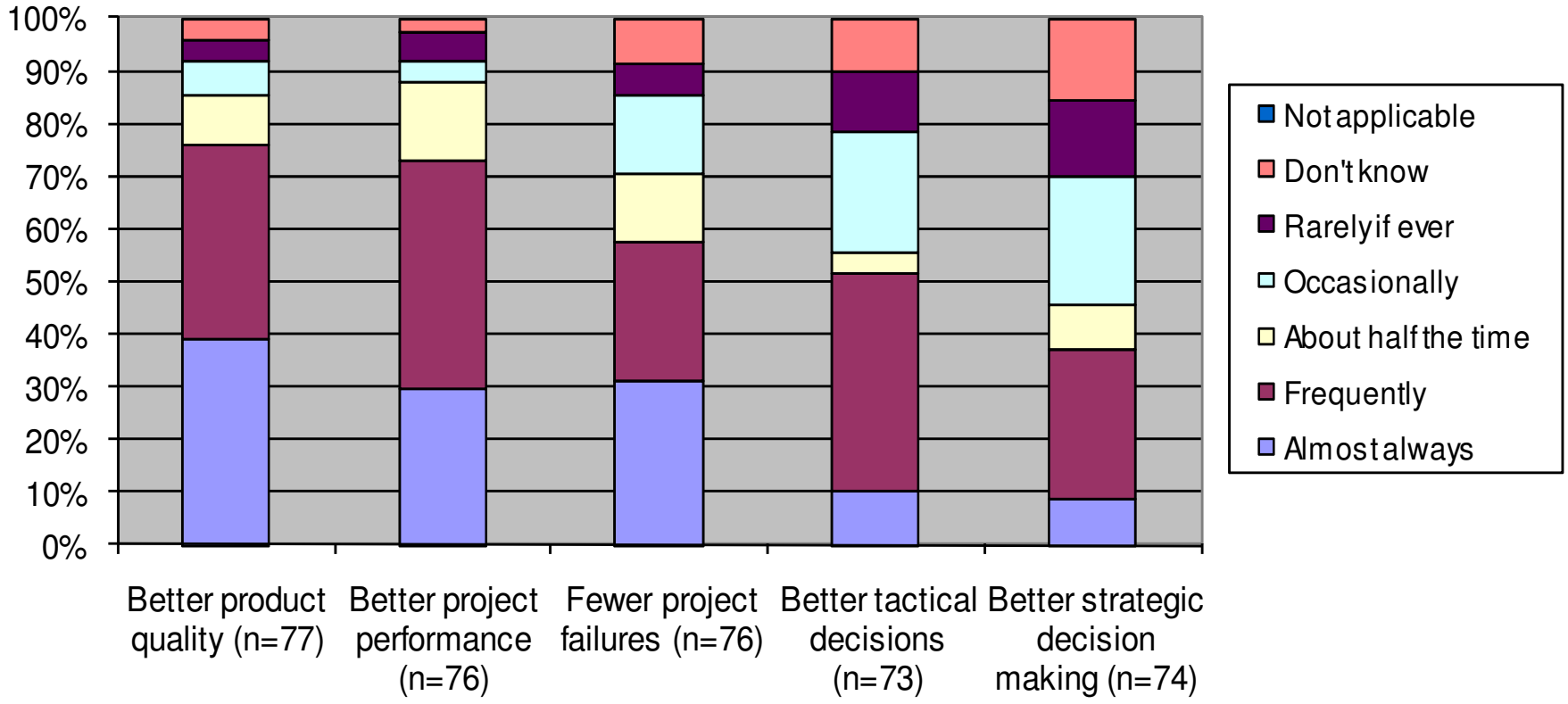
- Understanding & reported use of process performance models
- Use of various analytical methods & management processes

Whether or not the organizations achieved their appraised high maturity goals also varies predictably for the same reasons

We hope to see how & if high maturity organization sponsor perspectives continue to mirror those of HMLAs in future surveys

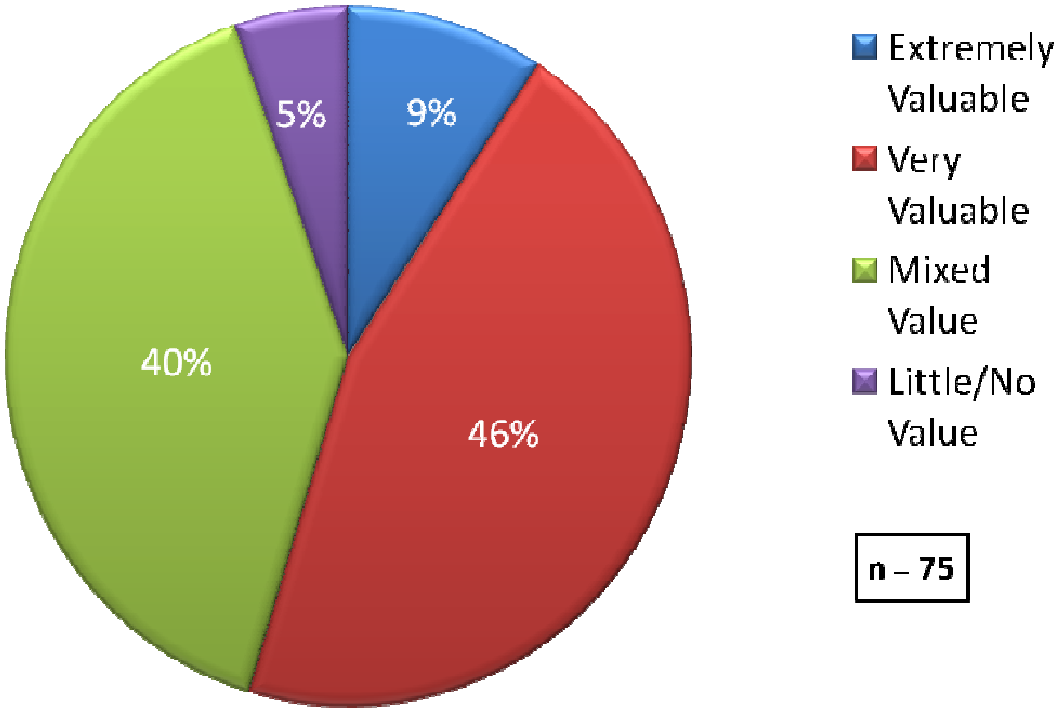
- ***With respect to increasing use of analytical techniques to inform decision-making***

2009: Statements about the possible results of using process performance modeling



Overall Value of PPMs

In your best judgment, how useful have process performance models been for this organization overall?



Extremely valuable:
they rely on them extensively

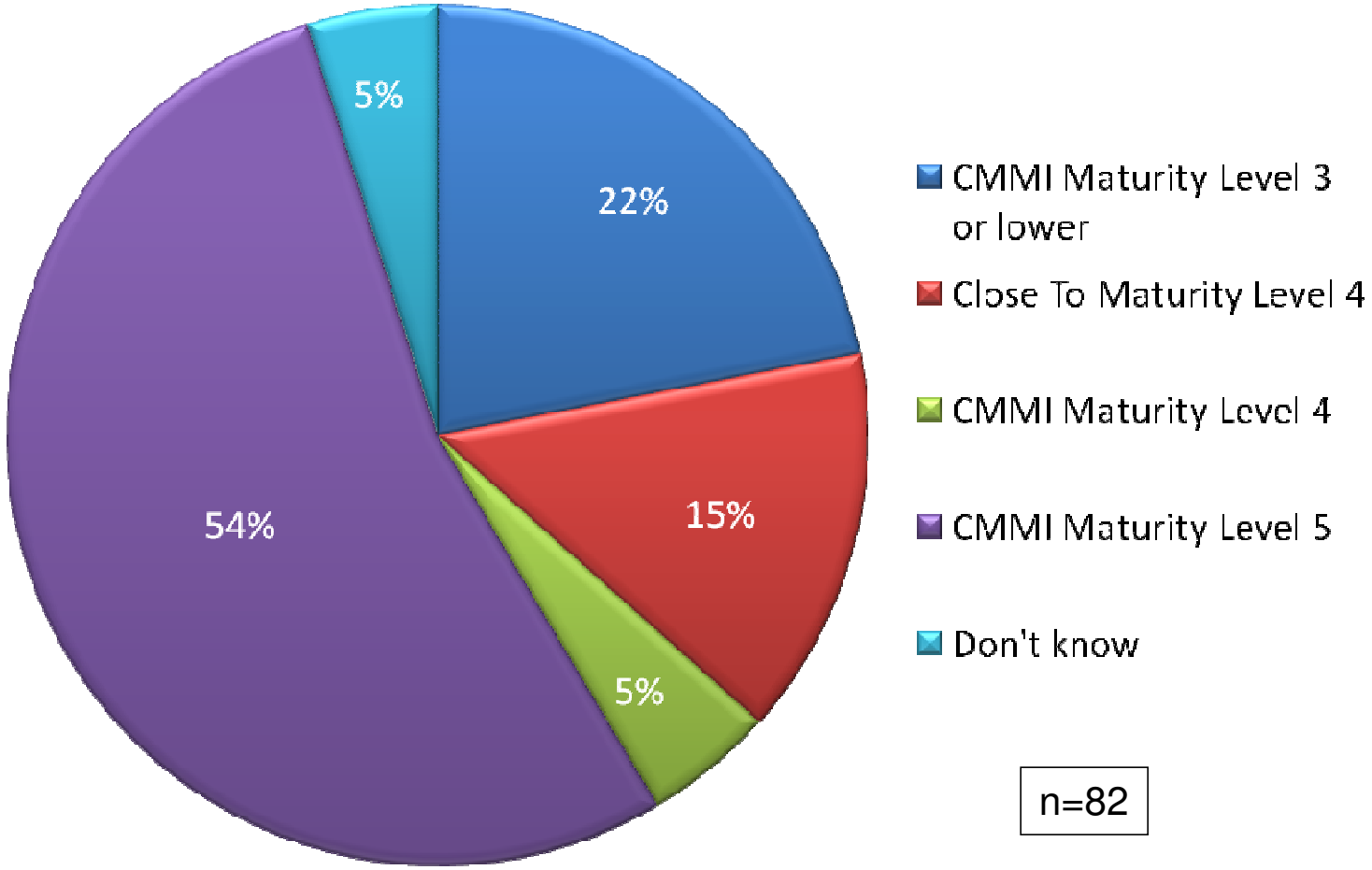
Very valuable:
they have obtained much useful information from them

Mixed value:
they have obtained useful information on occasion

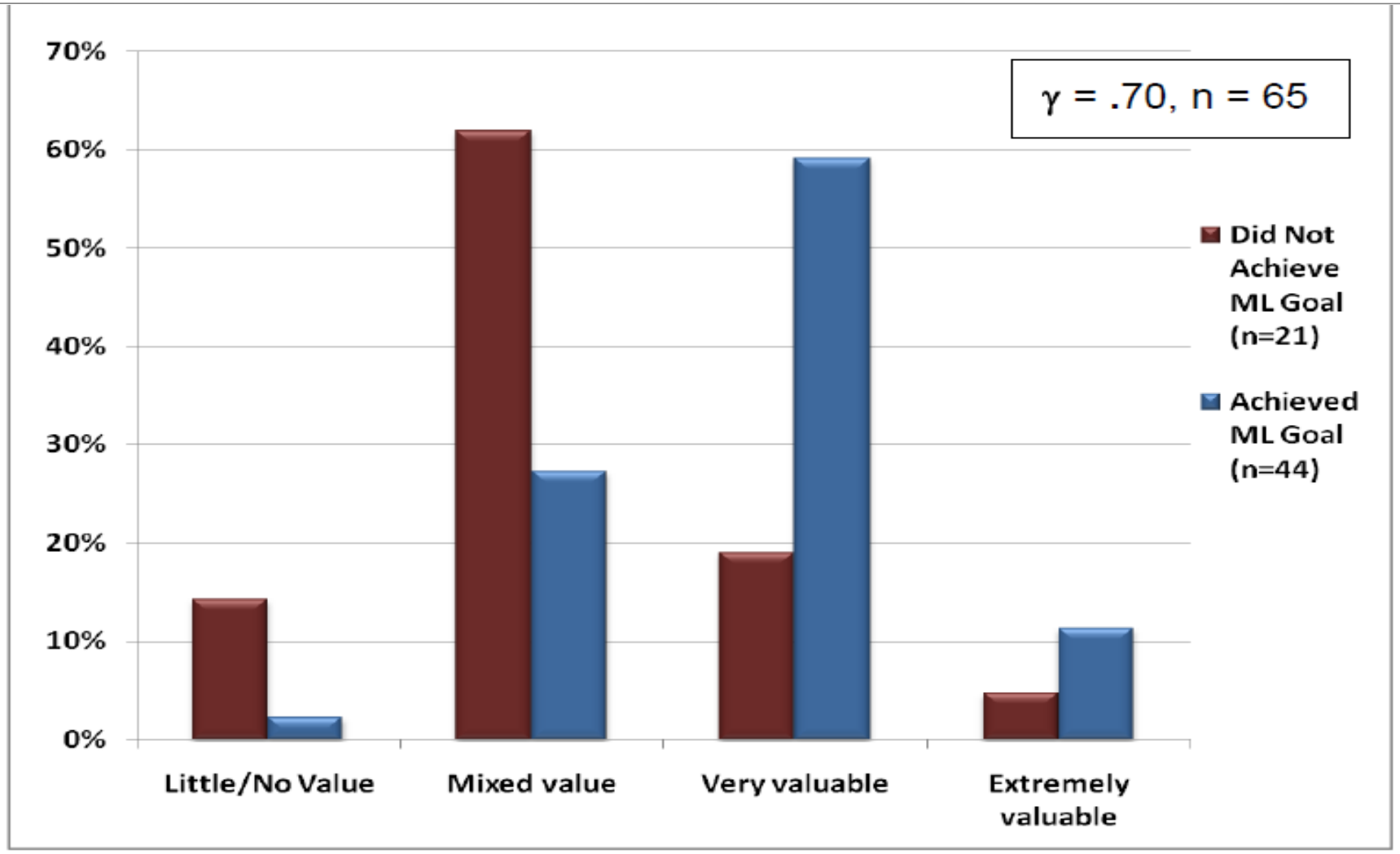
Little or no value

It's been harmful, not helpful

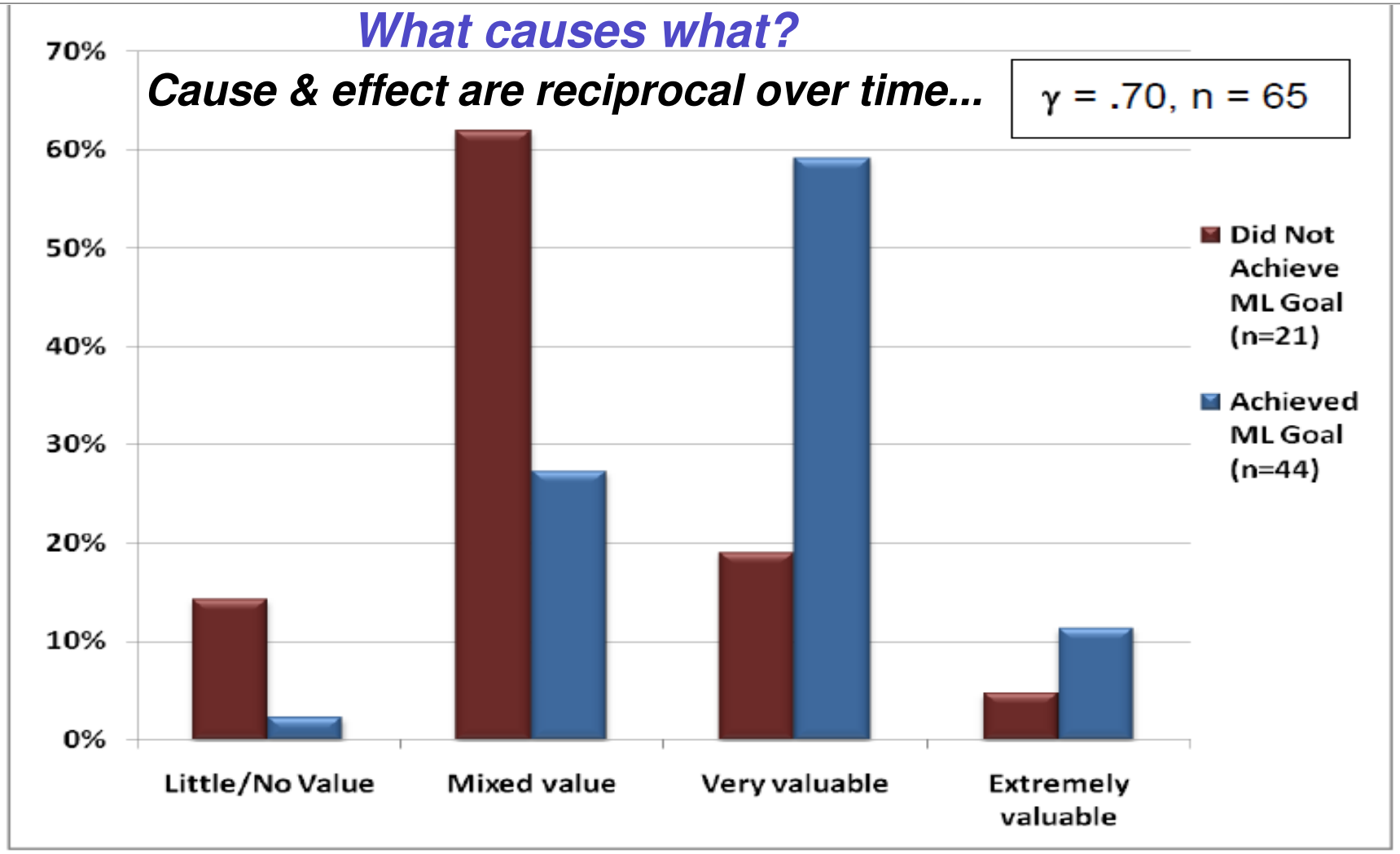
Achieved Maturity Level Varies Too



The Two are Closely Related



This may be the most important graphic in the whole presentation. Why?



The Chicken or the Egg?

Cause & effect may be reciprocal over time

- ***But it doesn't matter which comes first!***

Organizations that find value in their PPMs are more likely to achieve their HM goals

But achieving HM status also affects the likelihood that organizations will find additional value in creating & using an enhanced suite of PPMs

- Achieving HM status also affects the use of related analytical methods & model results to inform business and technical decision making

Some organizations undoubtedly have implemented processes that are consonant with CMMI best practices for other reasons

- Especially early adopters of CMMI

But the fact of the matter is that they ***are*** CMMI best practices.

Selected Relationships

Not surprisingly: Strength of relationships with a wide variety of factors are often similar for both:

- Overall value attributed by HMLAs to use of process performance modeling
- Whether or not the organizations achieved their appraised high maturity level goals

They both vary predictably with:

- Understanding & reported use of process performance models
- Use of various analytical methods & management processes

See the TR & last year's presentation for more detail about overall value…

- (References & URLs are at the end of this presentation)

What follows here?

- The strongest relationships with achievement of high maturity level goals
- Highlighting instances where strength of those relationships differ from comparable relationships with overall value

Healthy PPM Ingredients: Emphasis

How much emphasis does the organization place upon the following in its process performance modeling?

- Accounting for uncertainty and variability in predictive factors and predicted outcomes
- Factors that are under management or technical control
- Other product, contractual or organizational characteristics, resources or constraints
- Segmenting or otherwise accounting for uncontrollable factors
- Factors that are tied to detailed subprocesses
- Factors that are tied to larger, more broadly defined organizational processes

Note that values on the extremes of this & all other weighted sum measures require consistency of replies across all of the component sub questions

Survey Composite Variables

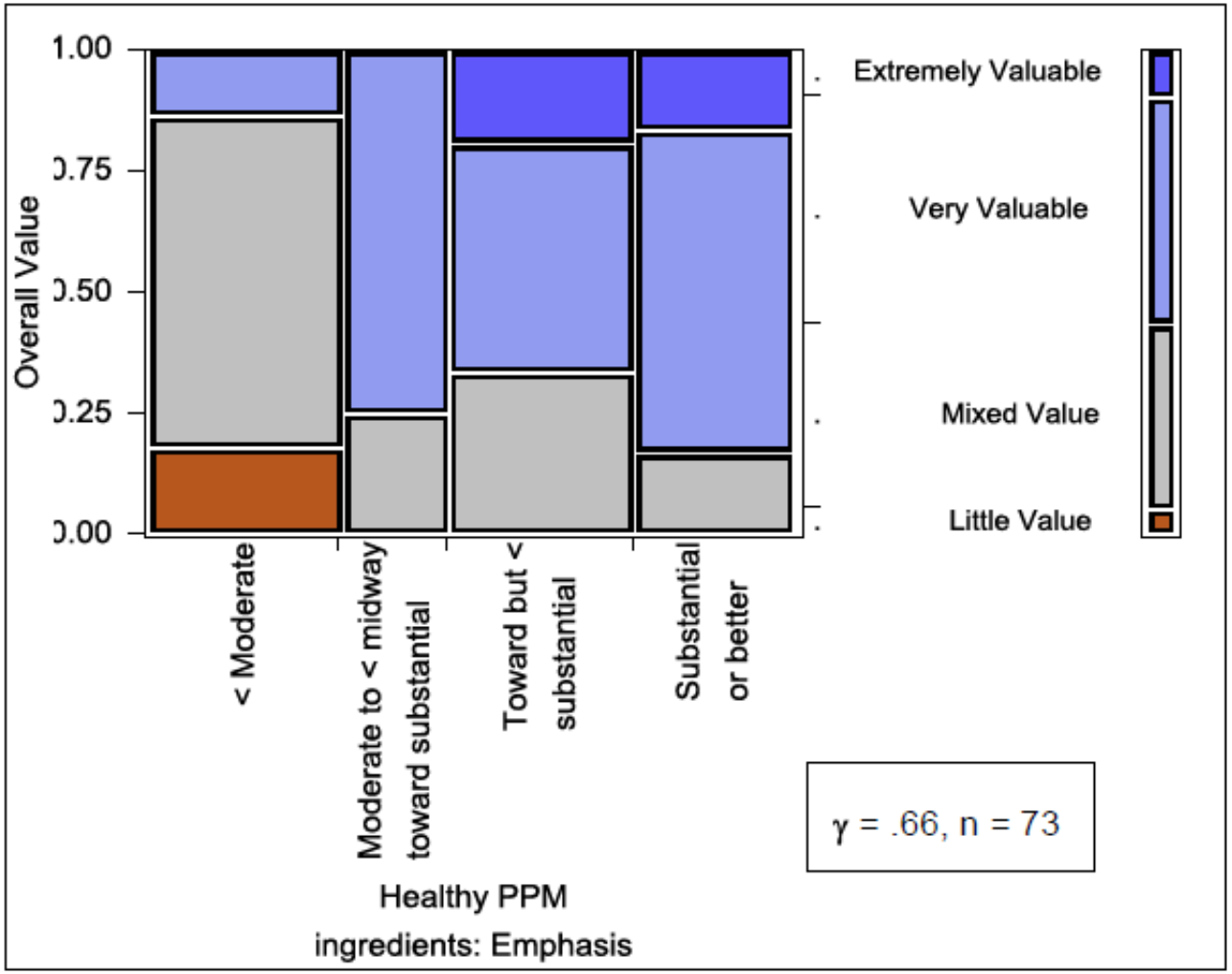
Many of the relationships described here use composite measures that are based on combinations of several related component questions. Each composite measures is based on the appraisers' answers to a group of related questions. The possible answers to those questions are ordinal categories such as extensive, substantial, moderate, limited & little if any.

Some of the composite measures are simple counts. Others such as this one are weighted, summed index of the respondents' answers to each of the questions. Much like a grade-point average, the answers are assigned ordered numeric values that are added and then divided by the number of valid answers to the series of questions for each respondent. For example extensive answers are scored as the value 5, substantial as 4, down to little if any as 1. Hence the values on the extremes of the weighted sum measures require consistency of replies across all of their respective component questions. The index scores are separated into categories based on the distribution of the total response values for ease of interpretation.

The weighting & summing are mathematically equivalent to an arithmetic mean; however, also much like a grade point average, the results are rank orders. Such indices are not interval- or ratio-level measures that can be added or multiplied meaningfully.

See Appendix C in CMU/SEI-2010-TR-022 (http://www.sei.cmu.edu/library/abstracts/reports/10tr022.cfm) for further detail.

Relationship Between Healthy PPM Ingredients & Overall Value Attributed to PPMs: Emphasis



Still room for improvement in PPM emphasis

Which does seem to pay off

Possible answers:

- **Extensive**
- **Substantial**
- **Moderate**
- **Limited**
- **Little if any**

Interpreting the Mosaics & Gamma

Most of the results described here summarize relationships between two variables. Many of them use a graphical mosaic such as this one to shows the extent to which the survey respondents' answers vary together in a consistent manner.

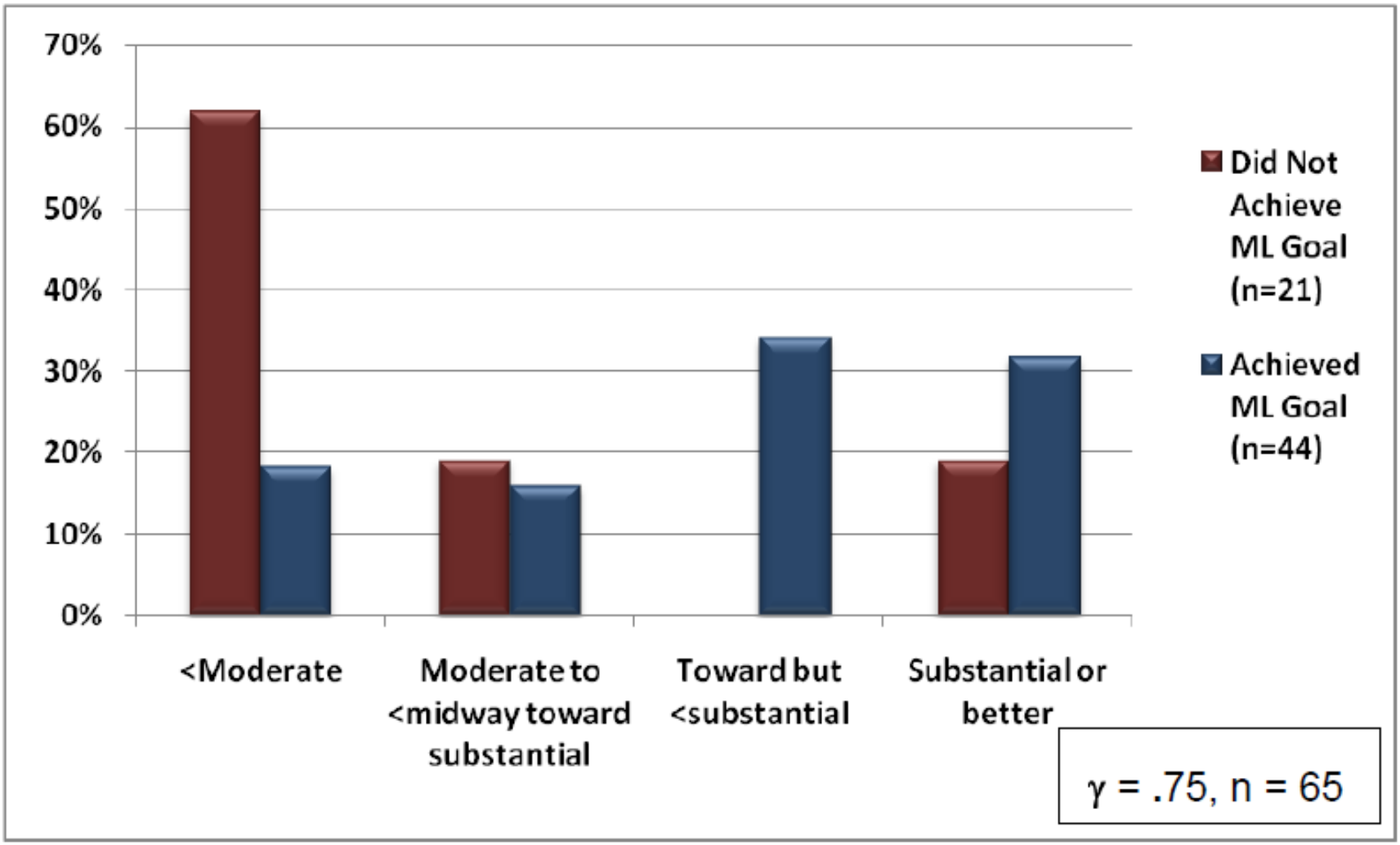
The values for each x-variable are displayed along the horizontal axis on the bottom of the mosaic, and labels for the respondents' answers to the y-factor are displayed to the right of the mosaic on the vertical axis. The proportions of responses for each category of the x-variable are shown in separate columns of the mosaic, where each value of the y-variable is represented in a separate mosaic tile. The width of each column varies in proportion to the number of responses for each category of the x-variable. This can provide a quick sense of how evenly or unevenly the survey answers are distributed.

The overall strength of the relationship between the two variables can be described by the value of the gamma statistic**. Gamma is an ordinal measure of association that is appropriate for ordered categorical measures such as these. It is symmetric, which means that its value will be the same regardless of which variable is considered to be an x-variable or a y-variable.**

The value of gamma is the proportion of paired comparisons where knowing the rank order of one variable reduces the proportionate error in predicting the rank order of the other variable. So, for example, if gamma is .75 then knowing the independent variable reduces our error in predicting the rank of the dependent variable by 75 percent.

See Appendix C in CMU/SEI-2010-TR-022 (http://www.sei.cmu.edu/library/abstracts/reports/10tr022.cfm) for further detail.

Healthy PPM Ingredients & Achievement of Appraisal Maturity Level Goal: Emphasis

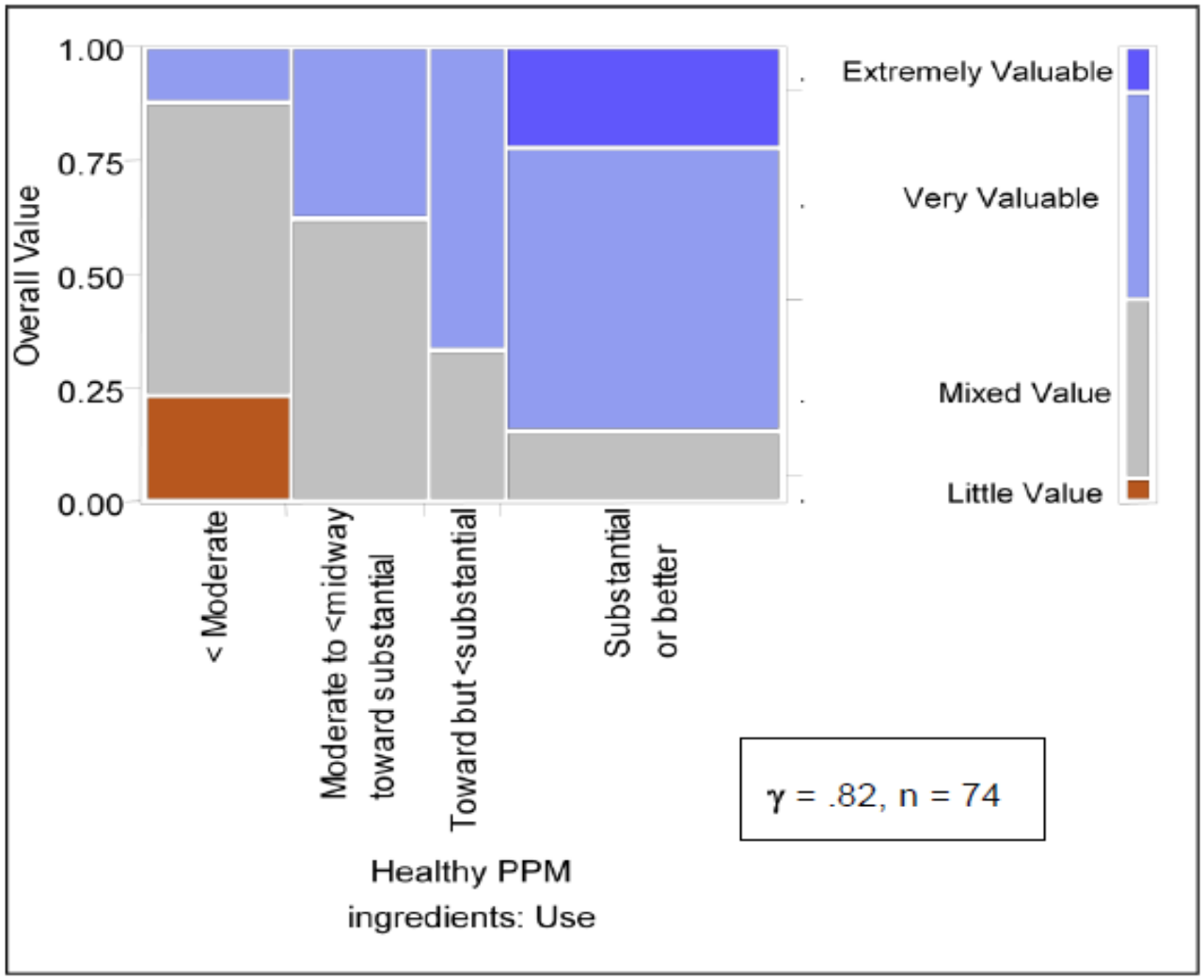


Healthy PPM Ingredients: Purpose

To what degree are your organization's process performance models used for the following purposes?

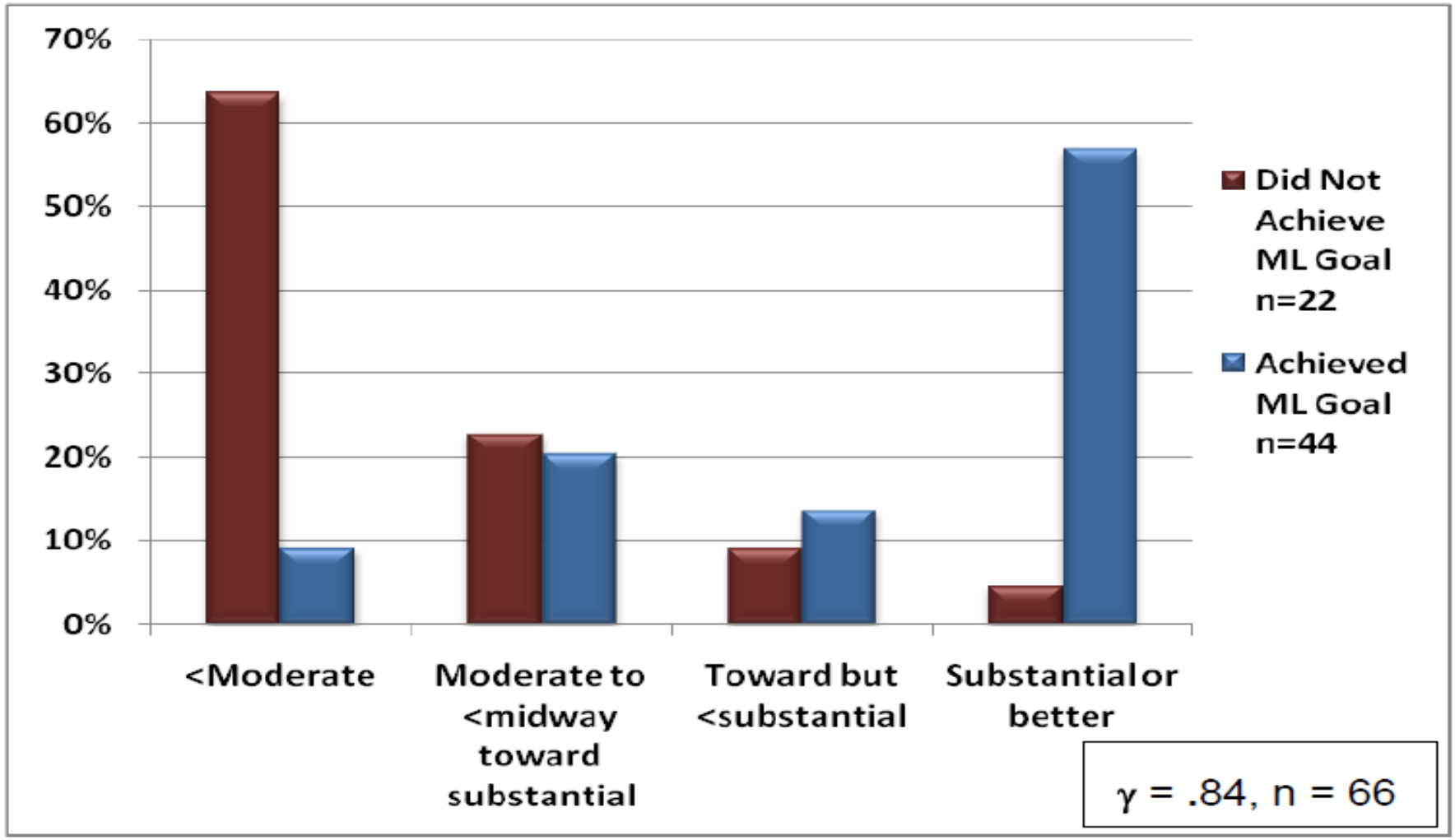
- Predict final project outcomes
- Predict interim outcomes during project execution (e.g., connecting "upstream" with "downstream" activities)
- Model the variation of factors and understand the predicted range or variation of the predicted outcomes
- Enable "what-if" analysis for project planning, dynamic re-planning and problem resolution during project execution
- Enable projects to achieve mid-course corrections to ensure project success

Relationship Between Healthy PPM Ingredients & Overall Value Attributed to PPMs: Purpose



More do report using PPMs for the right reasons

Healthy PPM Ingredients & Achievement of Appraisal Maturity Level Goal: Purpose

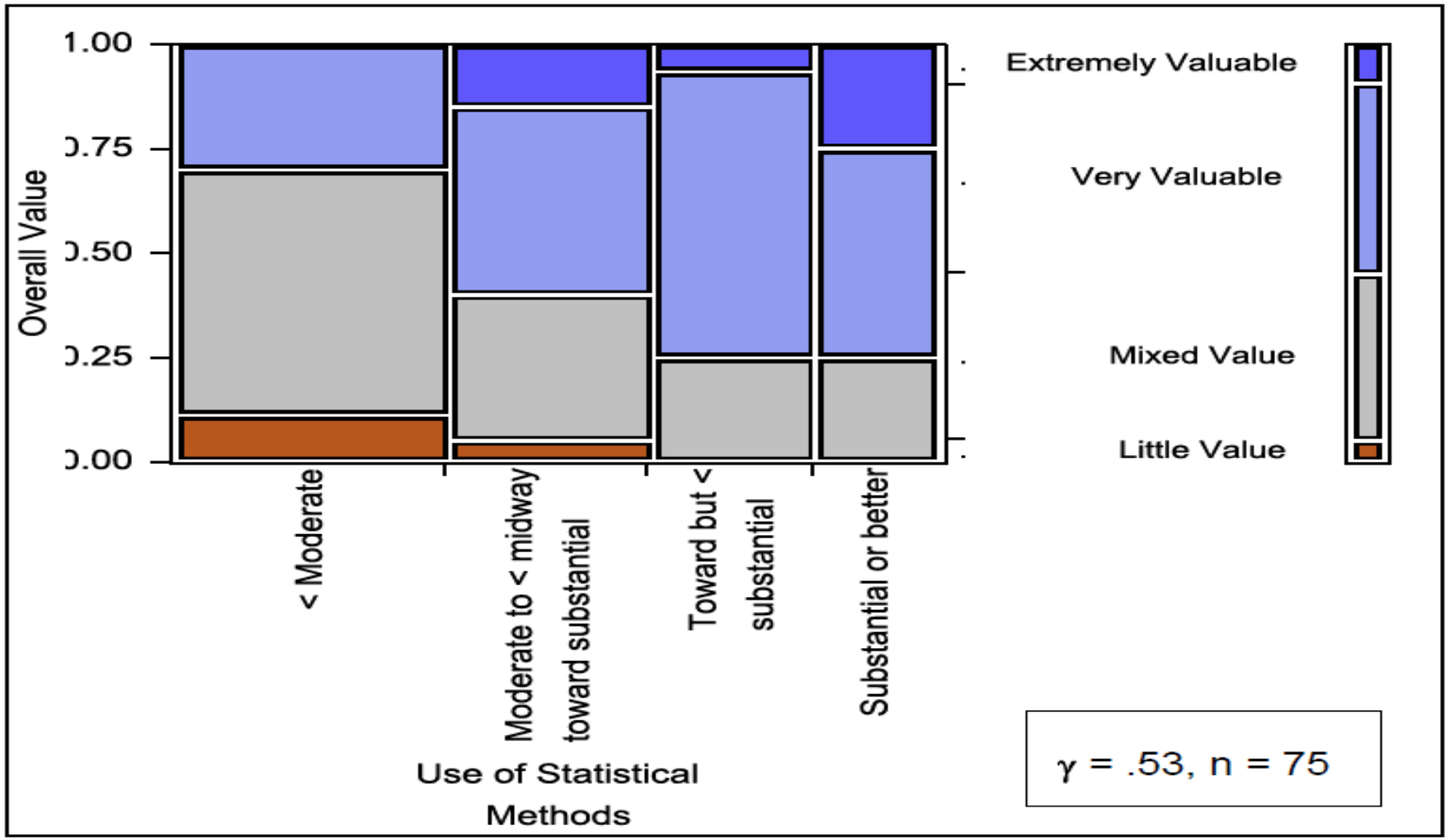


Statistical Analysis Methods

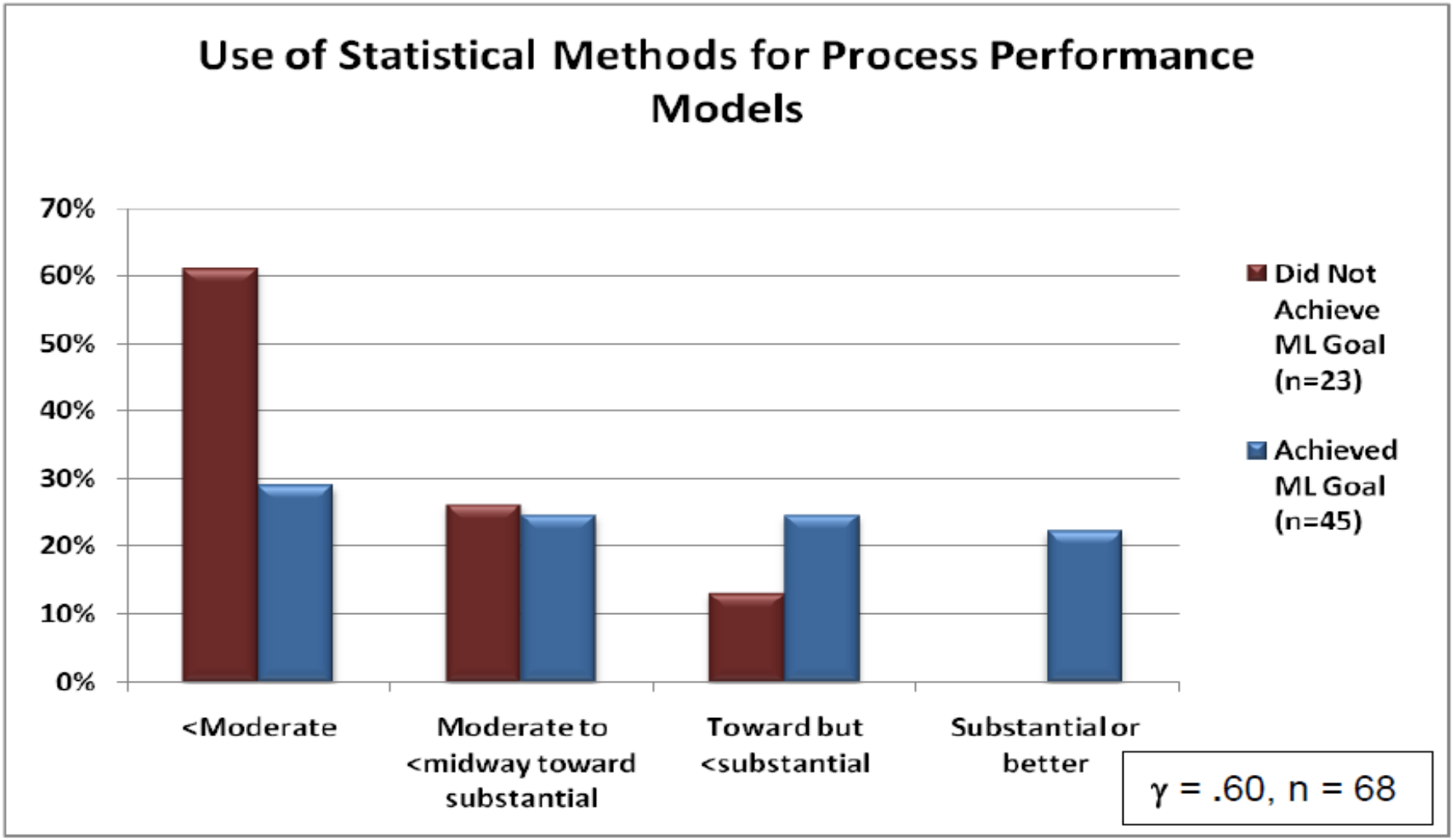
To what extent are the following statistical methods used in the organization's process performance modeling?

- Regression analysis predicting continuous outcomes (e.g., bivariate or multivariate linear regression or non-linear regression)
- Regression analysis predicting categorical outcomes (e.g., logistic regression or loglinear models)
- Analysis of variance (e.g., ANOVA, ANCOVA or MANOVA)
- Attribute SPC charts (e.g., c, u, p, or np)
- Individual point SPC charts (e.g., ImR or XmR)
- Continuous SPC charts (e.g., XbarR or XbarS)
- Design of experiments

Relationship Between Use of Multiple Statistical Methods & Overall Value Attributed to PPMs



Use of Multiple Statistical Methods & Achievement of Appraisal Maturity Level Goal

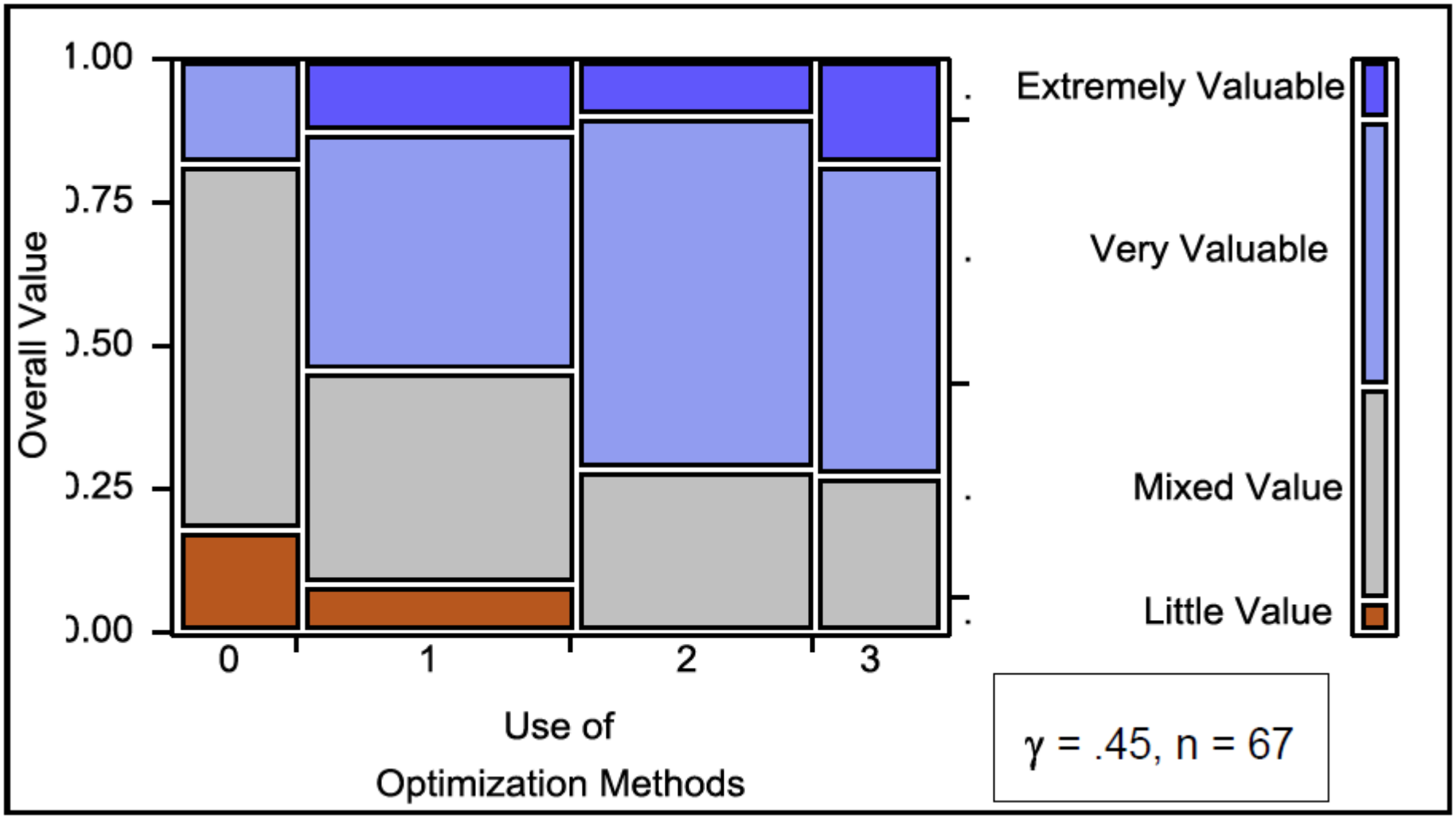


Simulation/ Optimization Techniques

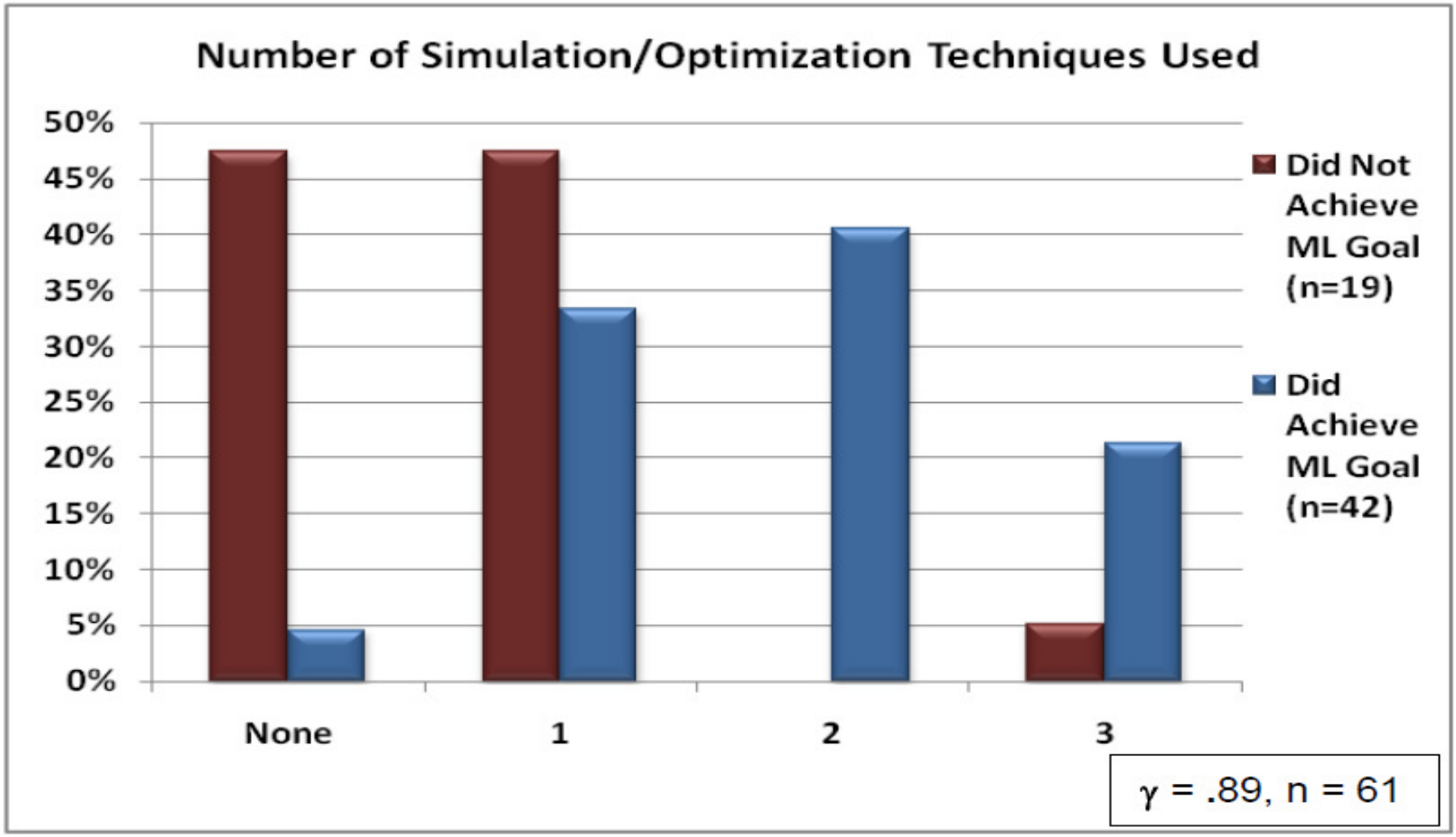
Which of the following other optimization approaches are used in your organization's process performance modeling?

- Monte Carlo simulation
- Discrete event simulation for process modeling
- Markov or Petri-net models
- Probabilistic modeling
- Neural networks
- Optimization

Relationship between # of Simulation/Optimization Techniques used & overall value attributed to PPMs

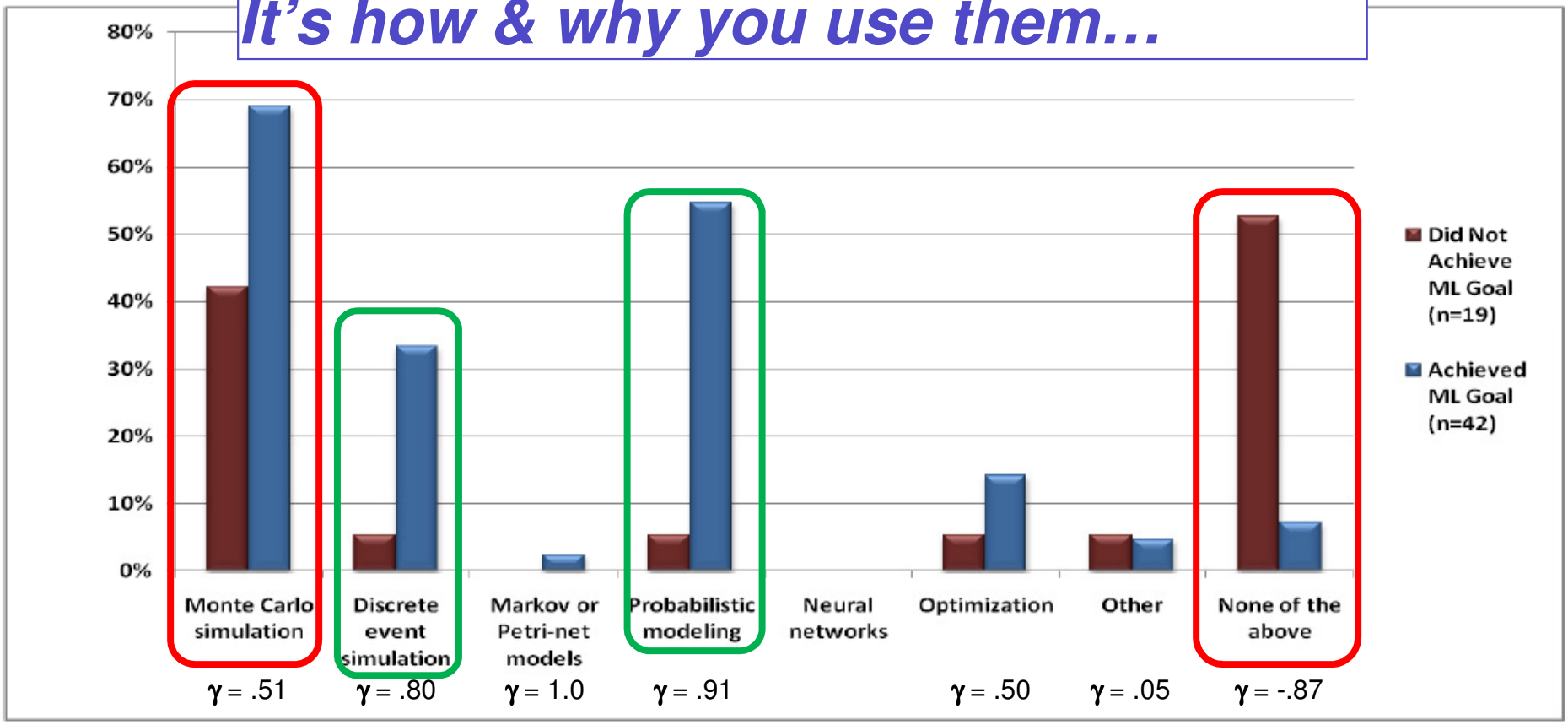


of Simulation/Optimization Techniques Used & Achievement of Appraisal Maturity Level Goal



Use of Specific Simulation/Optimization Techniques & Achievement of Appraisal ML Goal

It's not just what techniques you use. It's how & why you use them…



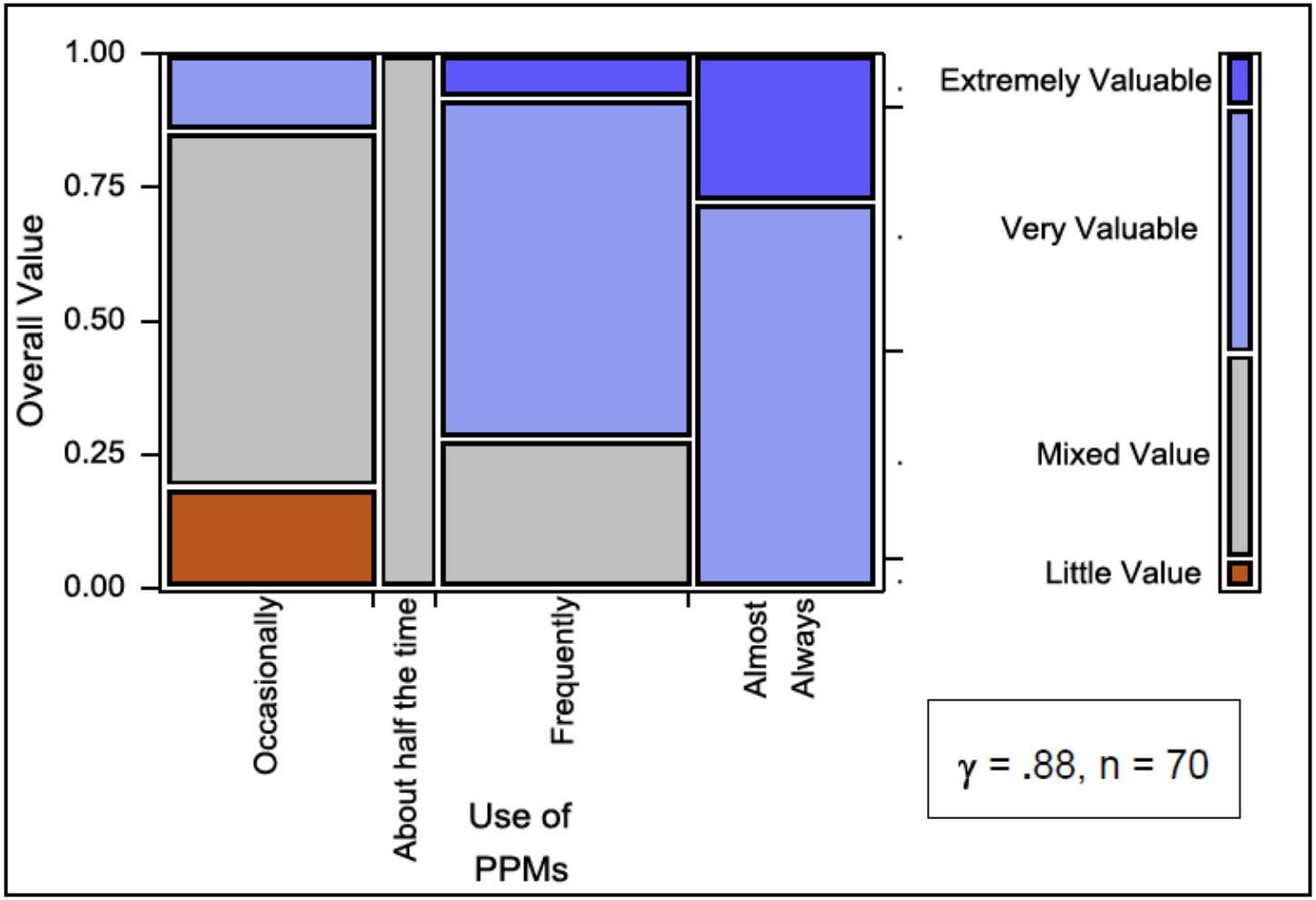
It's the uses to which the results are put…

Measurement & analytical methods aren't all that's important for achieving high maturity status

Management processes are important too!

- ***With active participation of the intended users of the measurement results***
- ***Who in turn are well equipped to understand the results***

Relationship Between Use of PPM Predictions in Reviews & Overall Value Attributed to PPMs

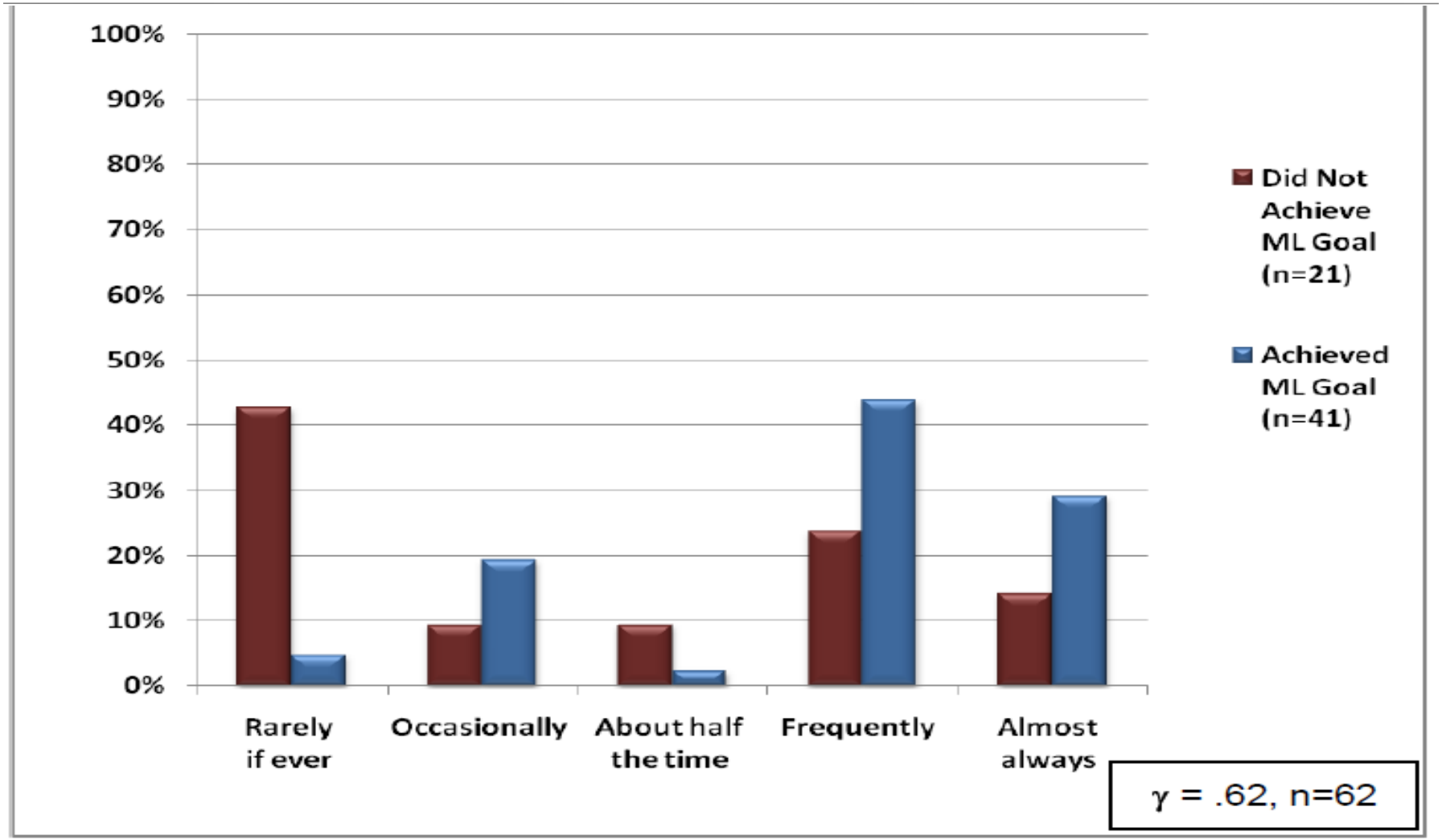


How often are process performance model predictions used to inform decision making in the organization's status and milestone reviews?

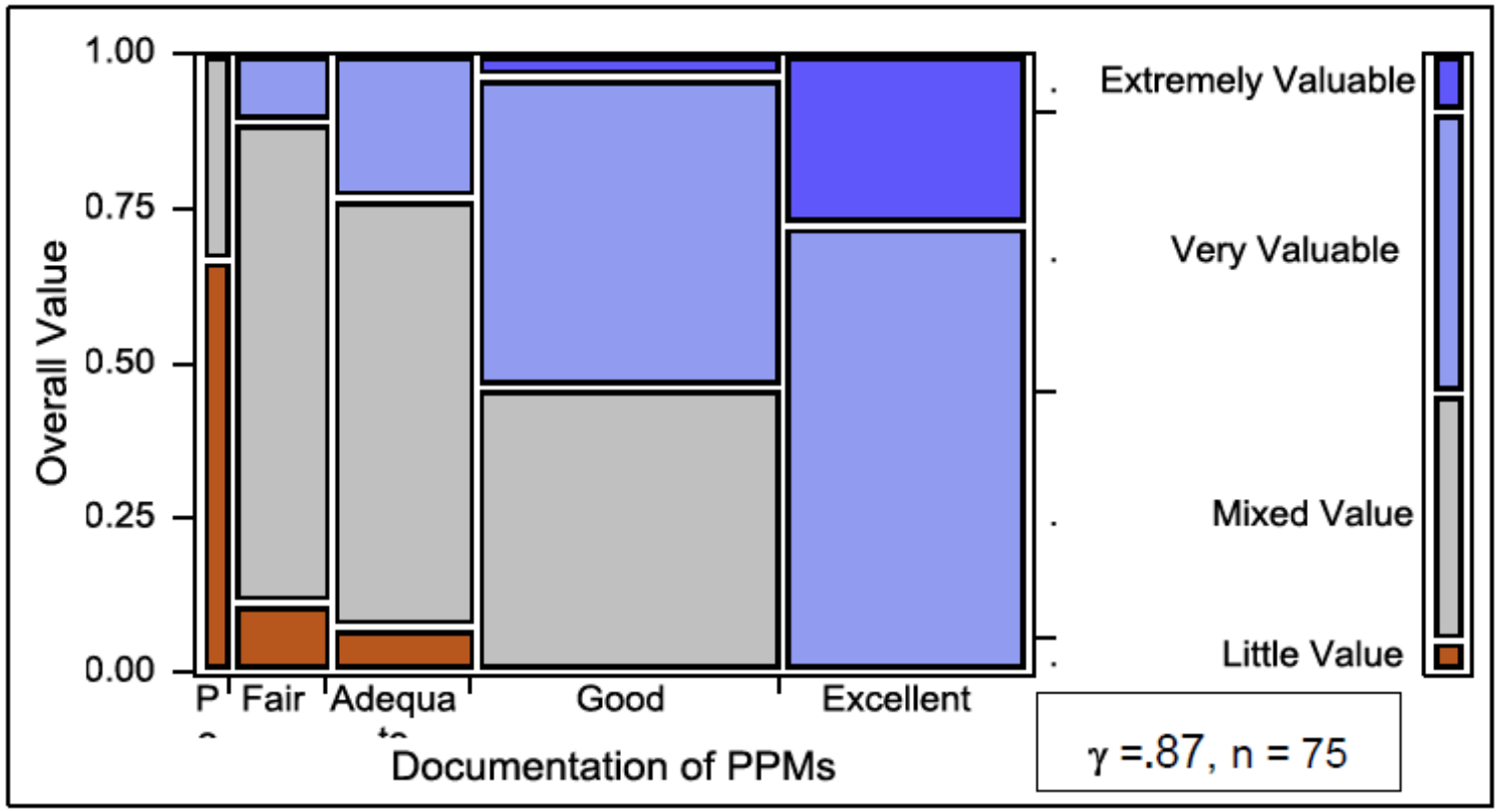
Of interest as a performance measure in its own right

Also for its impact on overall outcome

Use of PPM Predictions in Status/Milestone Reviews & Achievement of Appraisal ML Goal

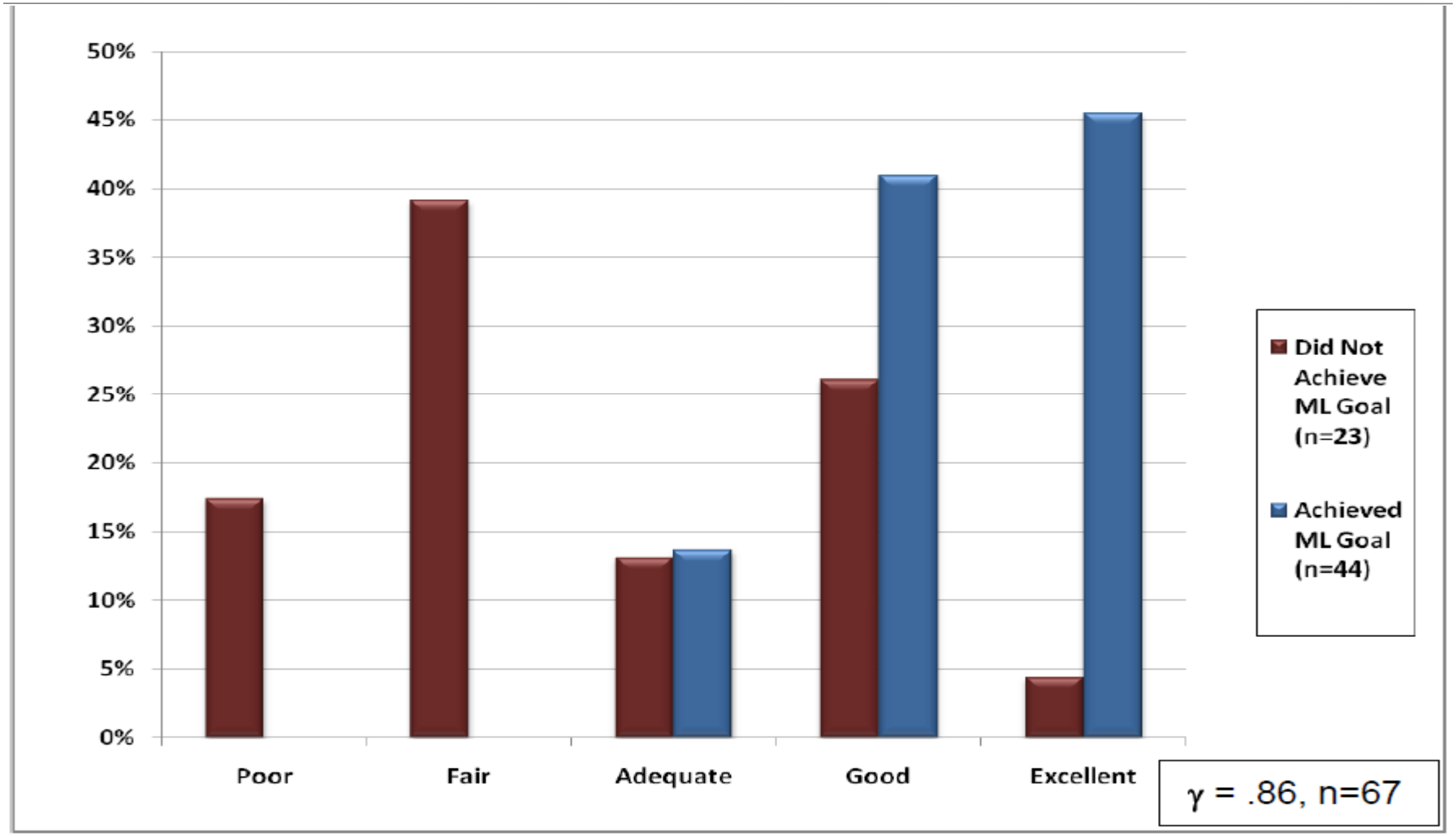


Quality of PPM Documentation & Overall Value Attributed to PPMs

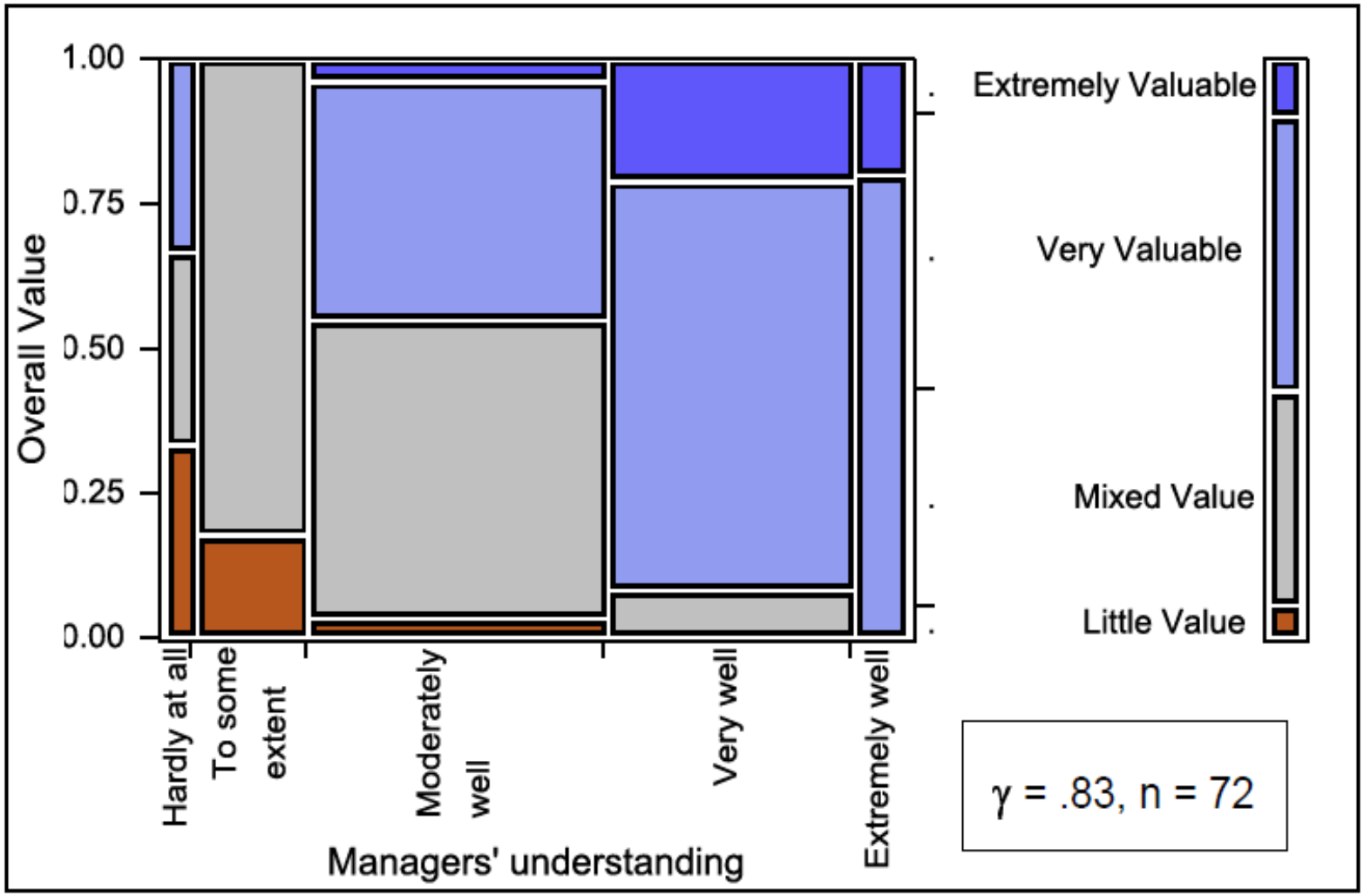


How would you best describe the organization's documentation of its process performance and quality measurement results (e.g., in the organization's PIIDs, measurement repository or process asset library)?

Quality of PPM Documentation & Achievement of Maturity Level Appraisal Goal

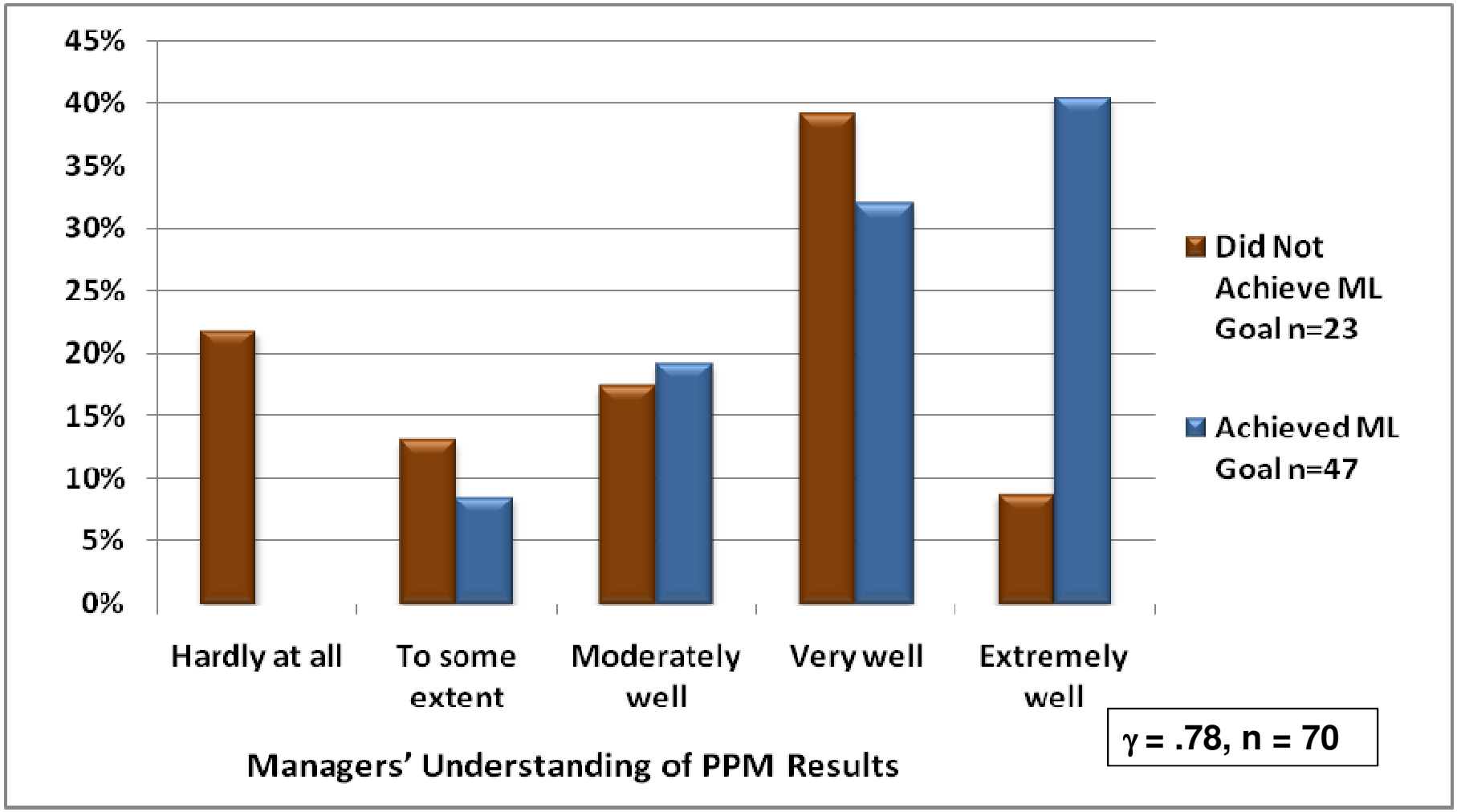


Relationship Between Managers' Understanding of Model Results & Overall Value Attributed to PPMs



How well do the managers in the organization who use process performance model results understand the results that they use?

Relationship Between Managers' Understanding of Model Results & Achievement of ML Goal



Stakeholder Involvement

How would you characterize the involvement of various potential stakeholders in setting goals and deciding on plans of action for measurement and analysis in your organization?

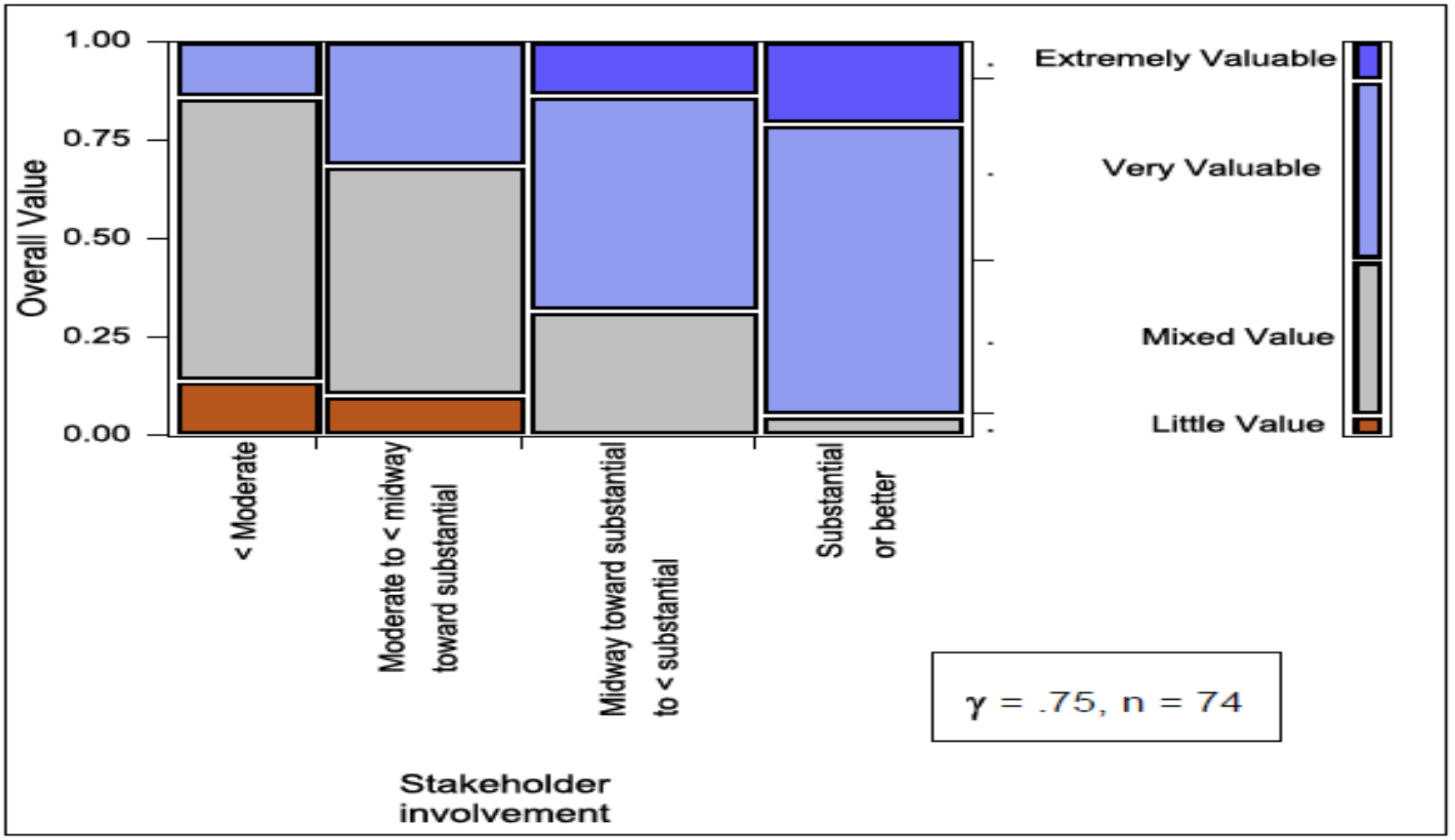
- Customers
- Executive and senior managers
- Middle managers (e.g., program or product line)
- Project managers
- Project engineers and other technical staff
- Process and quality engineers
- Measurement specialists

As per GQ(I)M

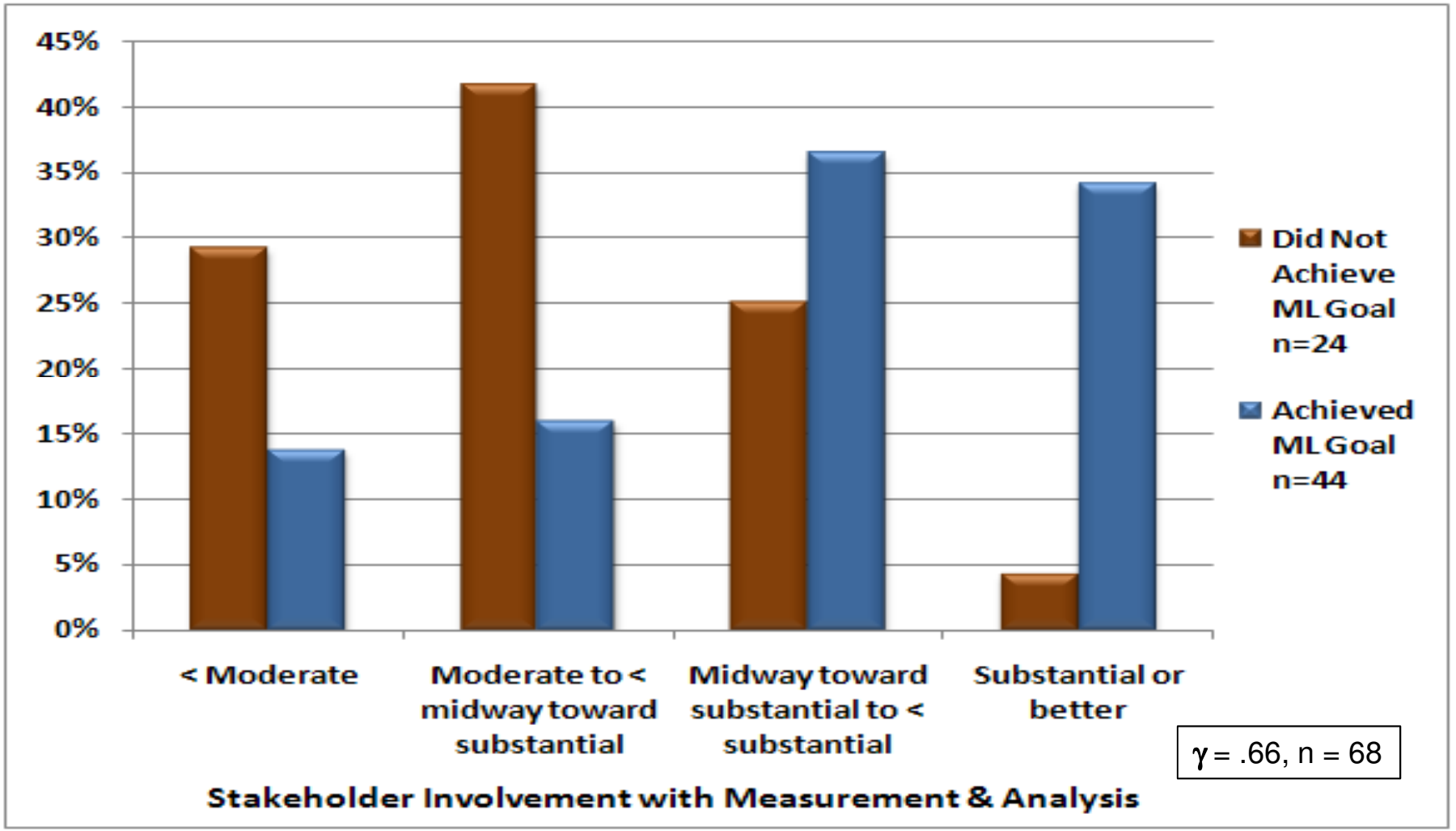
Measurement & Analysis SG1, SP1

As well as GP 2.7

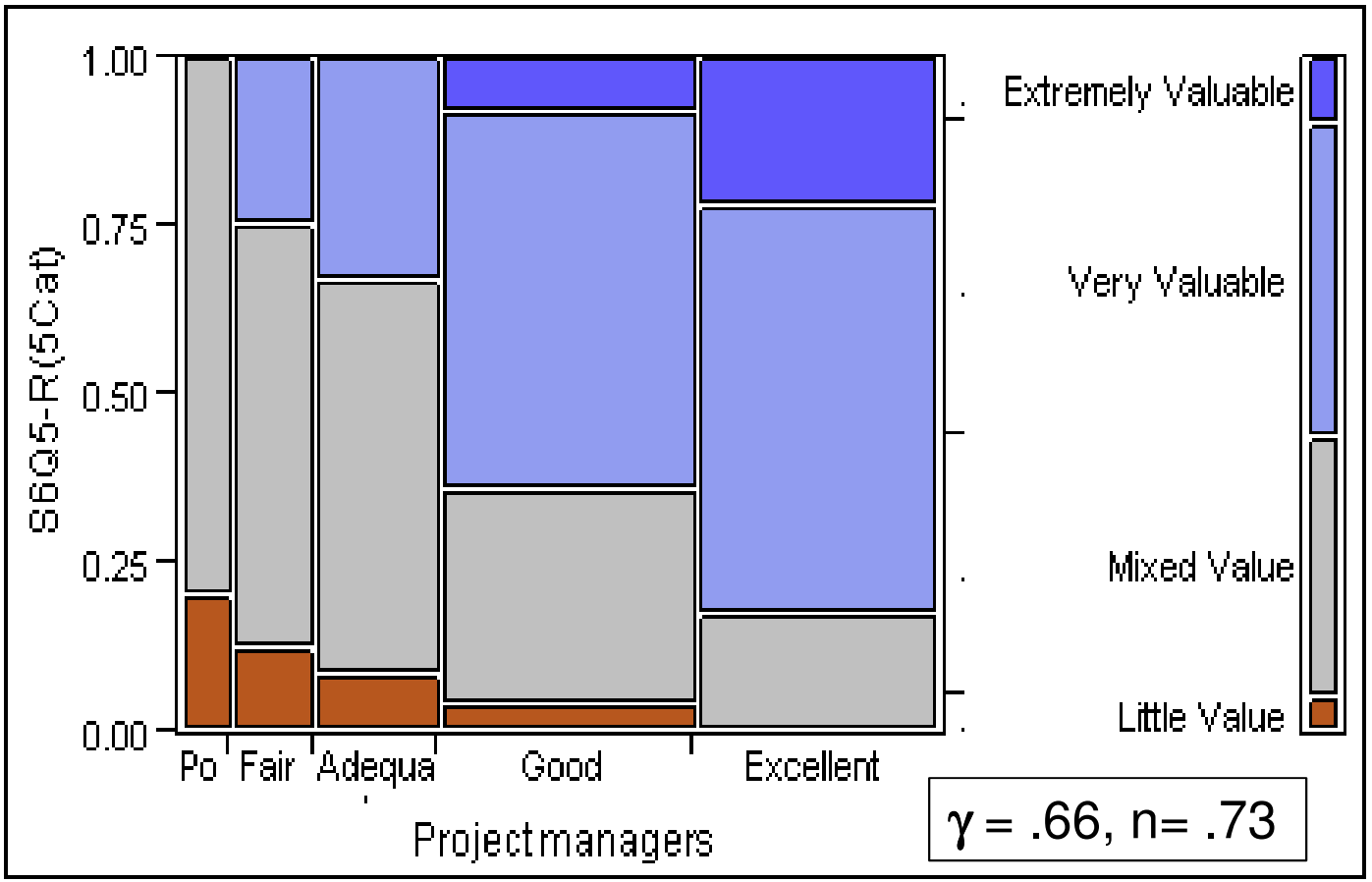
Relationship Between Stakeholder Involvement & Overall Value Attributed to PPMs



Relationship Between Stakeholder Involvement & Achievement of ML Goal

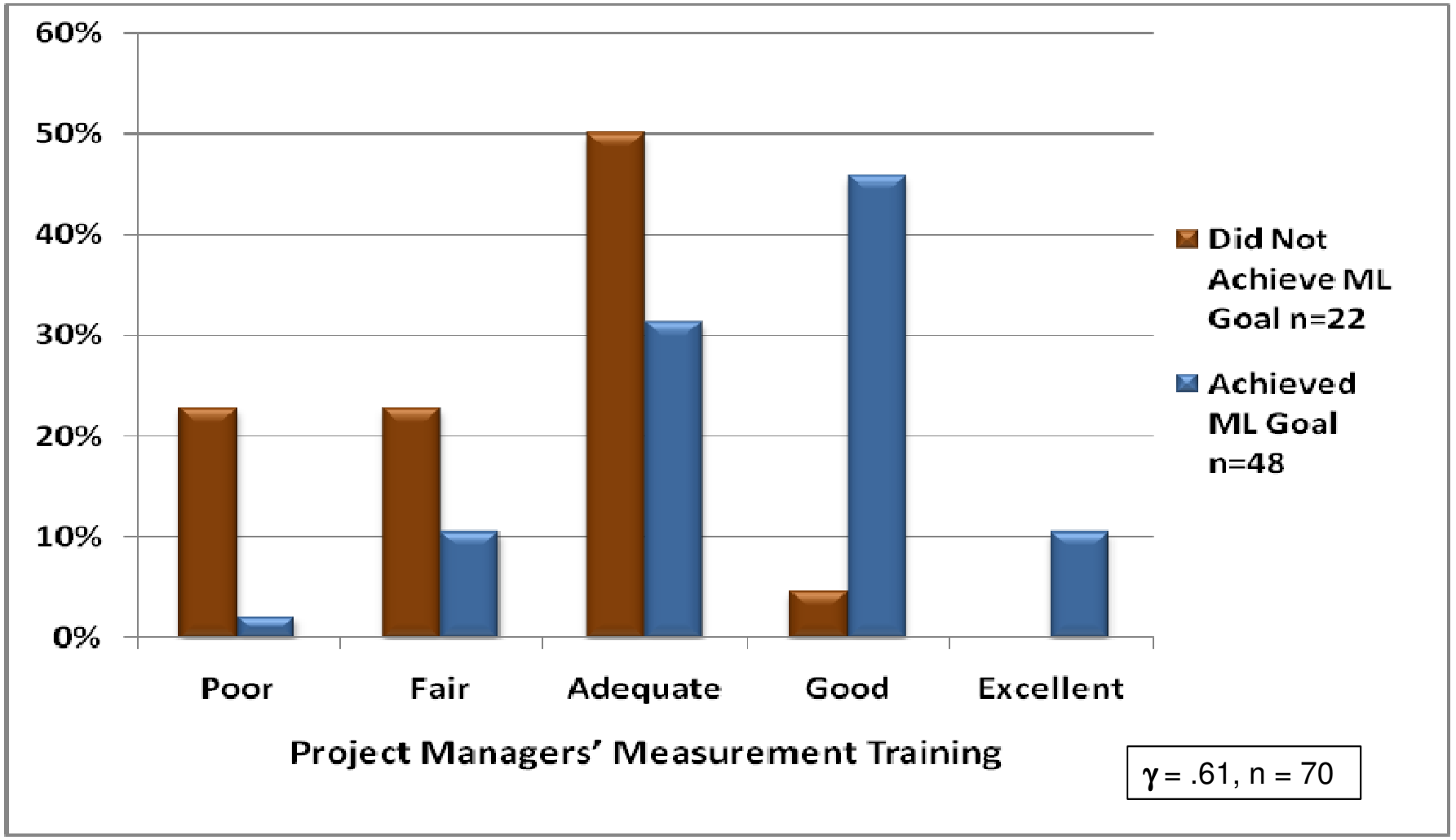


Relation Between Quality of Project Manager Training & Overall Value Attributed to PPMs



How would you best characterize the measurement related training that is available (for project managers) in the organization?

Relation Between Quality of Project Manager Training & Achievement of ML Goal



Today's Talk

Scope of the presentation

More results from the 2009 high maturity survey in the SEI's series of measurement & analysis state-of-the-practice sample surveys

Summary, lessons learned & next steps

Summary of Results$_1$

Overall value of process performance modeling & related activities was judged to be more valuable for organizations that:

- ***Understood & used measurement & analysis activities more frequently***
- ***Provided organizational resources & management support for the work***

Organizations that achieved their appraised high maturity goals shared the same characteristics

- ***Moreover achievement of appraised high maturity status is closely associated with better project/program performance, product quality & organizational decision making***

Replies to both surveys were generally consistent even though the two groups are often thought to be quite different

Summary of Results$_2$

HMLAs were slightly less positive overall in judgments of value added

But somewhat ***more*** positive than the sponsors about consistent use of process performance modeling approaches & analytical methods

Some conjectures about ***why*** that is so

- The HMLAs were reporting about ***more recent*** appraisals & coaching engagements
- The HMLAs were basing their judgments on evidence gathered at the project or program level
- The sponsors have a better understanding about overall goals & objectives
  - Which may not be addressed by the process performance modeling

The Bottom Line Again...

Responses to 2009 survey of high maturity lead appraisers are consistent with the responses from representatives from appraised high maturity organizations surveyed in 2008

The community can be confident that the appraisers' judgments are consistent with the organizations' own views of the value of measurement & analysis to their work

References

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Robert W. Stoddard II, Dennis R. Goldenson, *Approaches to Process Performance Modeling: A Summary from the SEI Series of Workshops on CMMI High Maturity Measurement and Analysis*, CMU/SEI-2009-TR-021 (http://www.sei.cmu.edu/library/abstracts/reports/09tr021.cfm)

Dennis R. Goldenson, Michael J. Zuccher, Robert W. Stoddard II, Whitepaper & updated web links on CMMI performance results, forthcoming TBD

Thank You for Your Attention!

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Why do the 2008 & 2009 High Maturity Samples Differ?

Surveyed high maturity lead appraisers (HMLAs) in 2009

- Provides a useful comparison with those of the perspectives from the appraised organizations

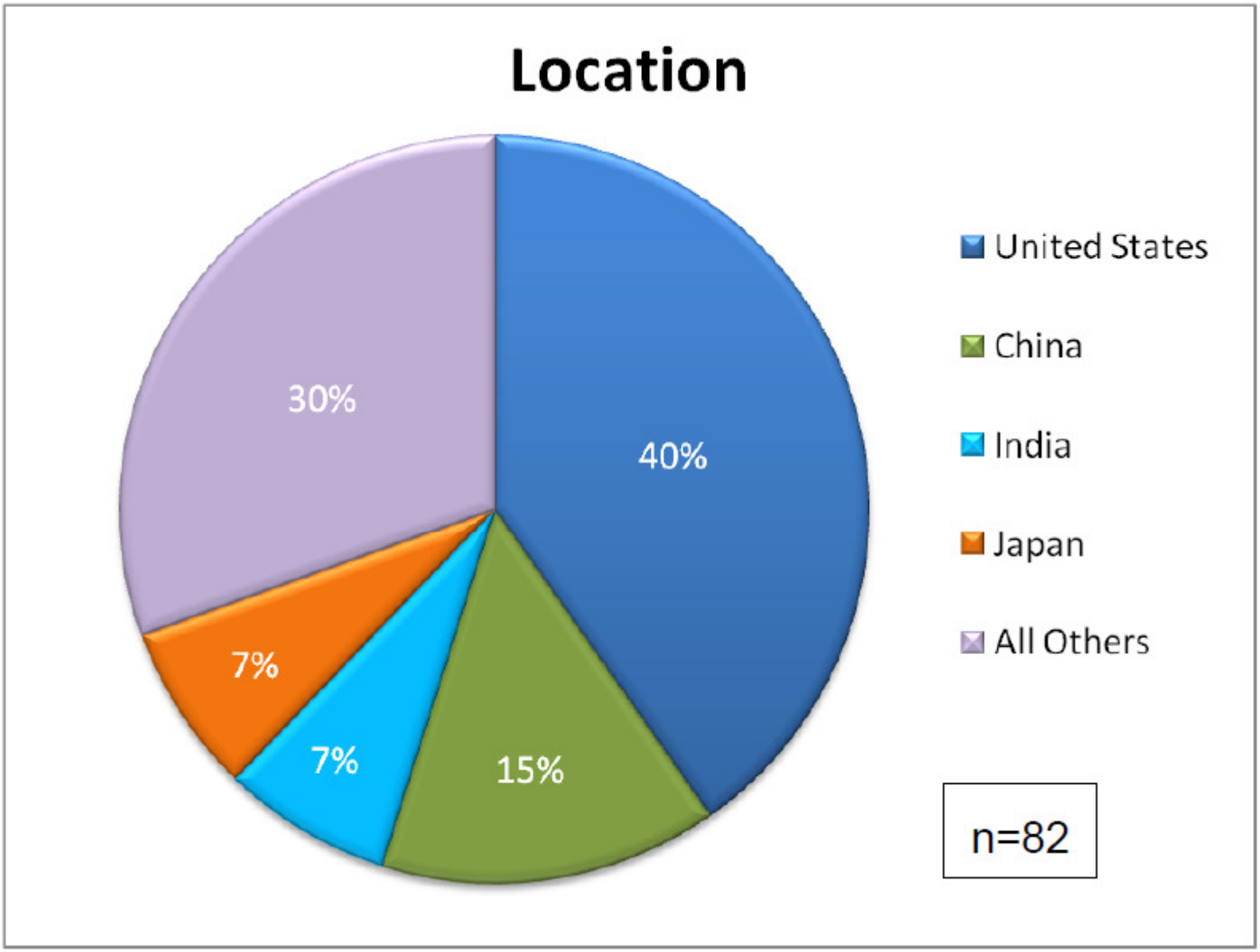
Intent has been to reuse & modify the 2008-2009 questionnaire in future years

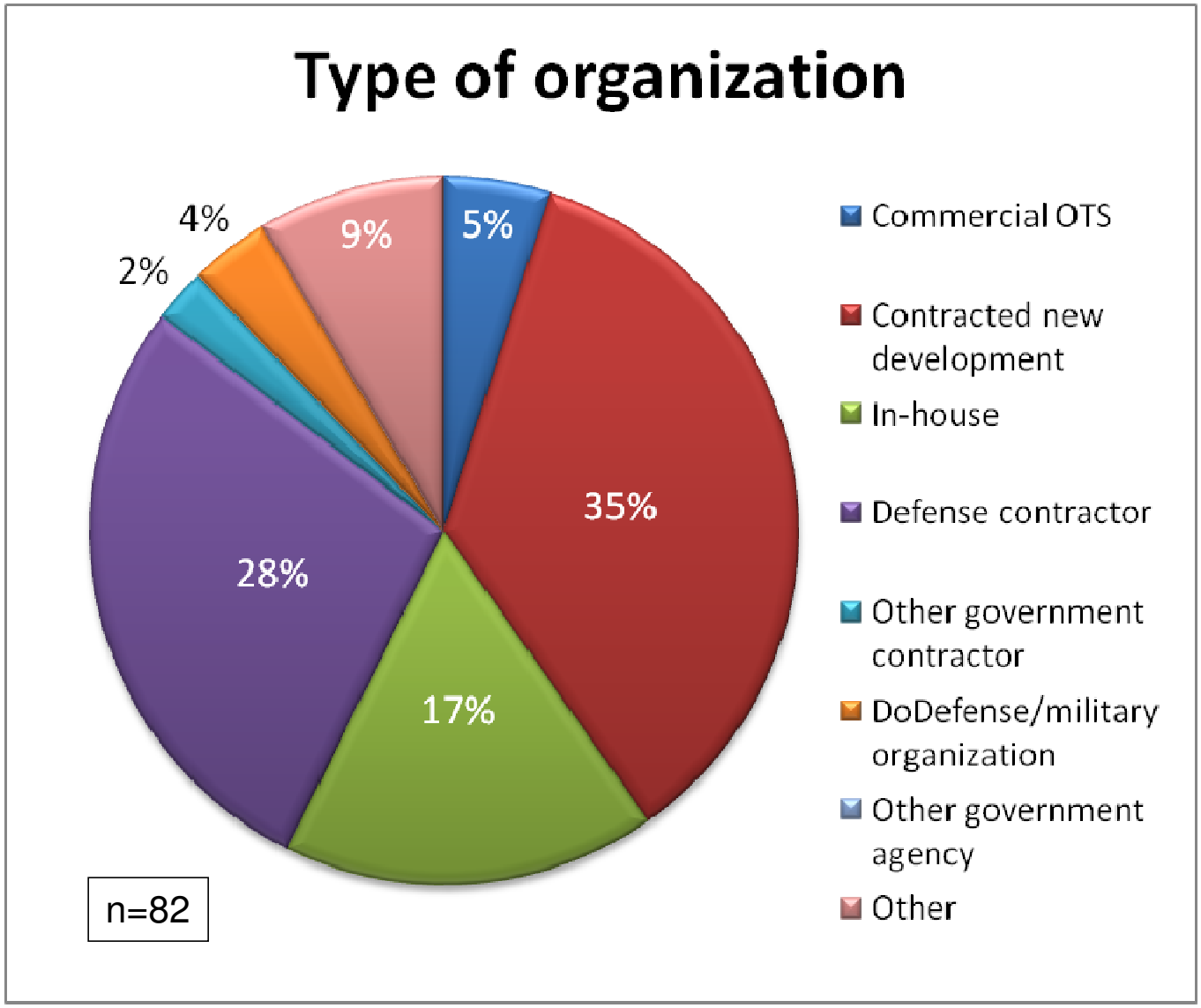
- Using the 2008 results as the baseline for tracking changes in high maturity organizations over time

Only a limited number of organizations have achieved high maturity status

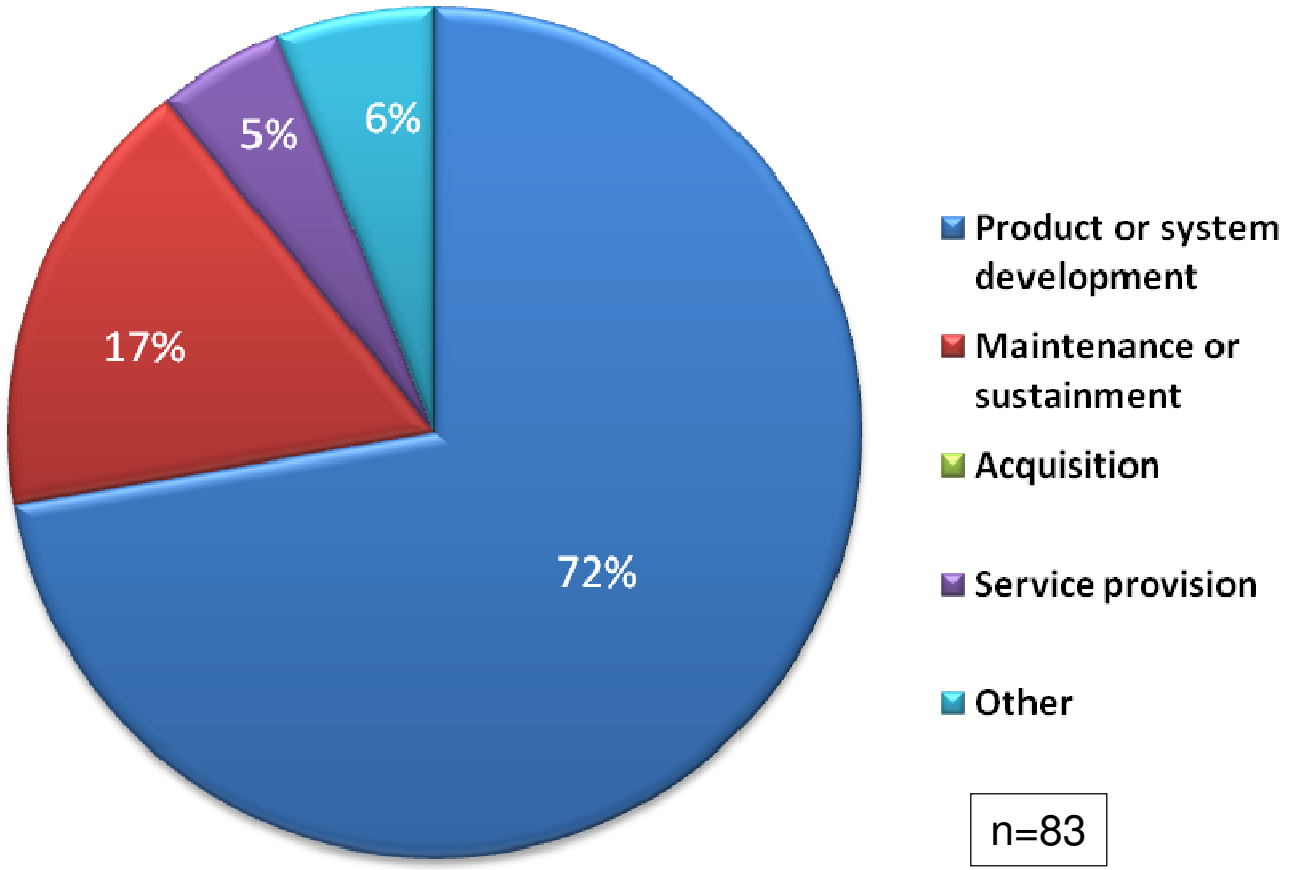
But we won't ask the same people to answer the same questions over & over each year

- (Surveyed appraisal sponsors & their designees in 2008)

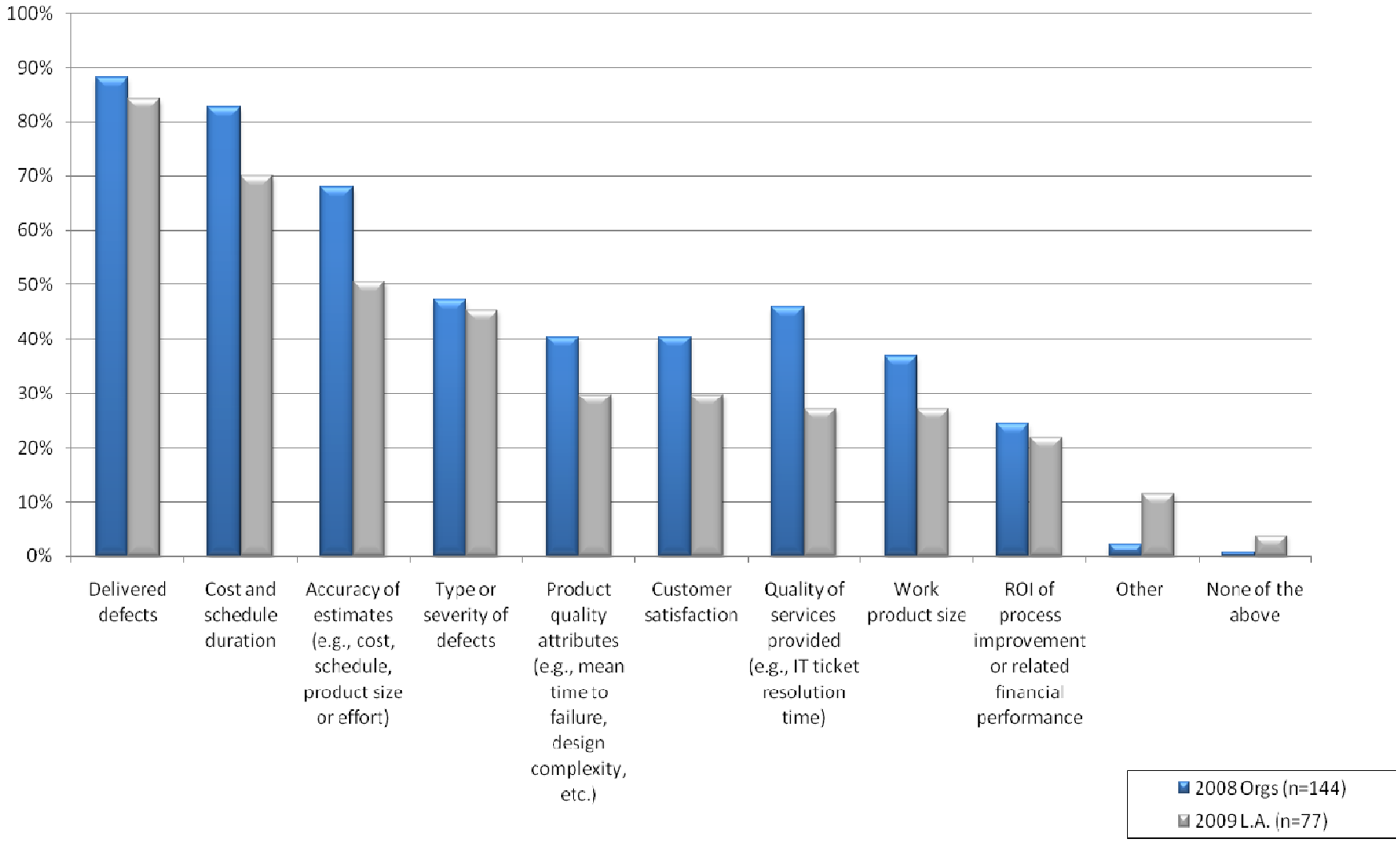




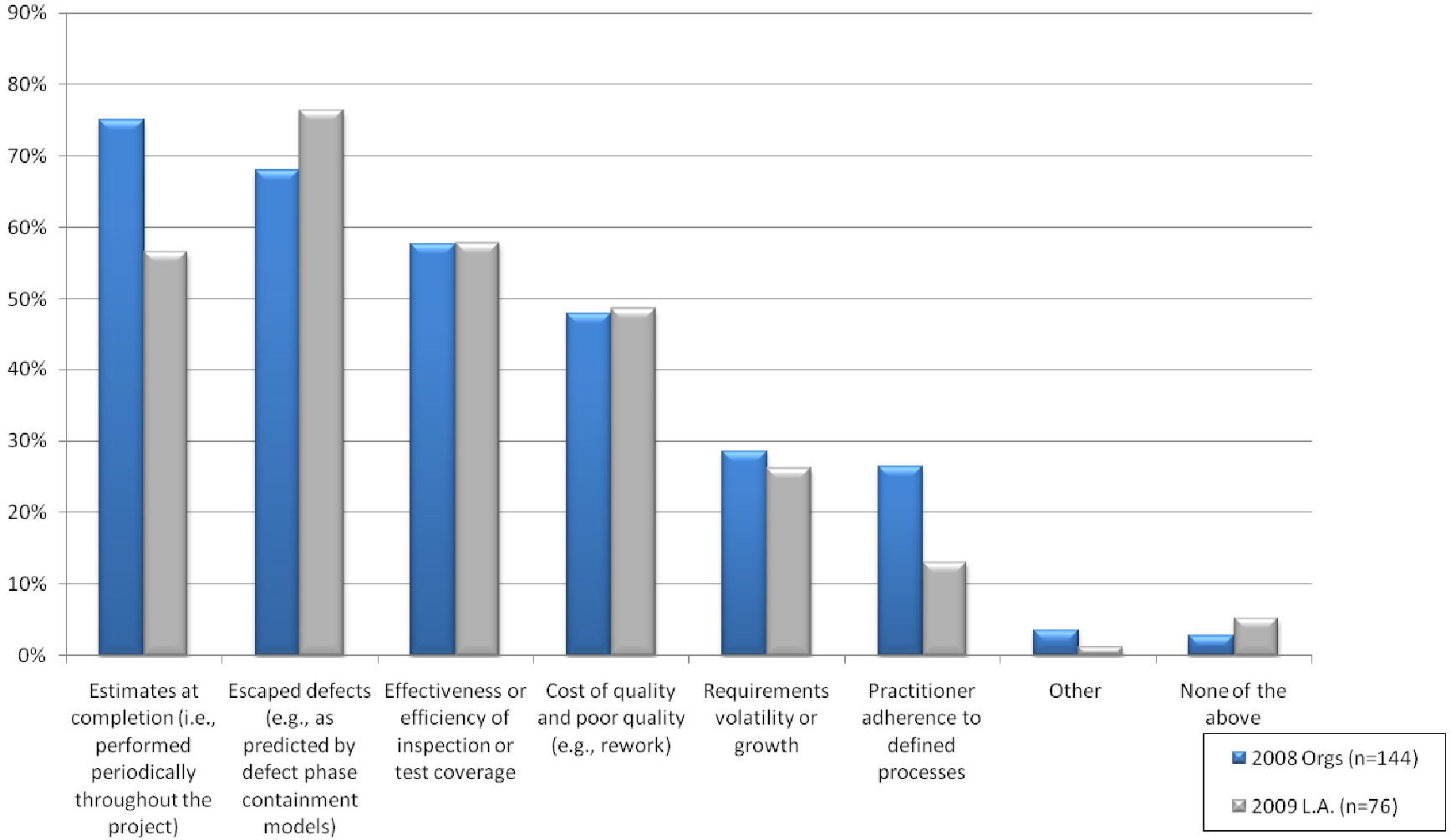
Primary focus of work

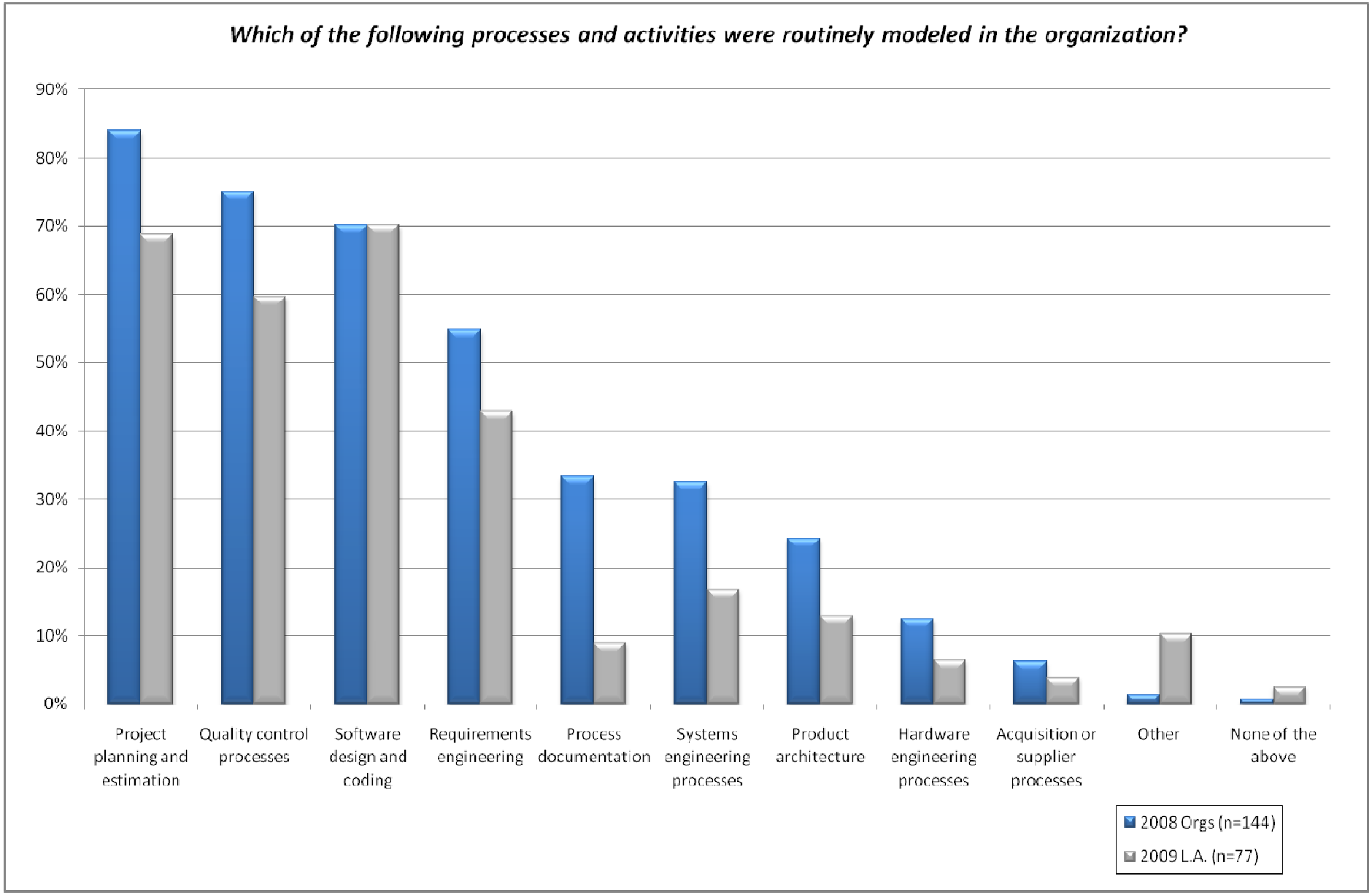


Which of the following product quality and project performance outcomes were routinely predicted with process performance models in the organization?



Which of the following (often interim) process performance outcomes are routinely predicted with process performance models in your organization?





Sampling Issues

Lower than desired response rates

Not surprising in relatively long questionnaires

Exacerbated by:

- Repeated contact of the same individuals for business as well as survey purposes
- Demands on time from busy executives

Considering other sampling strategies for future surveys

"State of the practice" also can refer to very different target populations

- The SEI customer base ... the broader software & systems engineering community ... or those organizations that more routinely use measurement?
- Of course, the population depends on the purposes of the survey