

# **Calibration of COCOMO II.2003**

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Cost Modeling

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# Outline

- • Characteristics of the current COCOMO II calibration data
  - Productivity
  - Age
  - Size
- Status of the 2003 model calibration

# Post-Architecture Model

- General effort estimation equation

$$\text{Person Months} = A \times (\text{Size})^E \times \prod_{i=1}^n \text{EM}_i$$

$$\text{where } E = B + 0.01 \times \sum_{j=1}^5 \text{SF}_j$$

- $A = 2.94$                        $B = 0.91$
- Size (thousands of lines of code, KSLOC, or function points)
- EM: Effort Multipliers (17 for PA)
- SF: Scale Factors (5 for both models)

# COCOMO II Driver Values

Cost_Driver	VL	L	N	H	VH	XH	PR
Precedentedness (PREC)	6.20	4.96	3.72	2.48	1.24	0.00	1.33
Development Flexibility (FLEX)	5.07	4.05	3.04	2.03	1.01	0.00	1.26
Architecture and Risk Resolution (RESL)	7.07	5.65	4.24	2.83	1.41	0.00	1.38
Team Cohesion (TEAM)	5.48	4.38	3.29	2.19	1.10	0.00	1.29
Process Maturity (PMAT)	7.80	6.24	4.68	3.12	1.56	0.00	1.43
Required Software Reliability (RELY)	0.82	0.92	1.00	1.10	1.26		1.53
Data Base Size (DATA)		0.90	1.00	1.14	1.28		1.42
Product Complexity (CPLX)	0.73	0.87	1.00	1.17	1.34	1.74	2.39
Develop for Reuse (RUSE)		0.95	1.00	1.07	1.15	1.24	1.31
Documentation Match to Life Cycle Needs (DOCU)	0.81	0.91	1.00	1.11	1.23		1.52
Time Constraint (TIME)			1.00	1.11	1.29	1.63	1.63
Storage Constraint (STOR)			1.00	1.05	1.17	1.46	1.46
Platform Volatility (PVOL)		0.87	1.00	1.15	1.30		1.50
Analyst Capability (ACAP)	1.42	1.19	1.00	0.85	0.71		2.00
Programmer Capability (PCAP)	1.34	1.15	1.00	0.88	0.76		1.77
Personnel Continuity (PCON)	1.29	1.12	1.00	0.90	0.81		1.59
Applications Experience (AEXP)	1.22	1.10	1.00	0.88	0.81		1.51
Platform Experience (PEXP)	1.19	1.09	1.00	0.91	0.85		1.40
Language and Tools Experience (LTEX)	1.20	1.09	1.00	0.91	0.84		1.43
Use of Software Tools (TOOL)	1.17	1.09	1.00	0.90	0.78		1.50
Multi-Site Development (SITE)	1.22	1.09	1.00	0.93	0.86	0.80	1.52
Required Development Schedule (SCED)	1.43	1.14	1.00	1.00	1.00		1.43

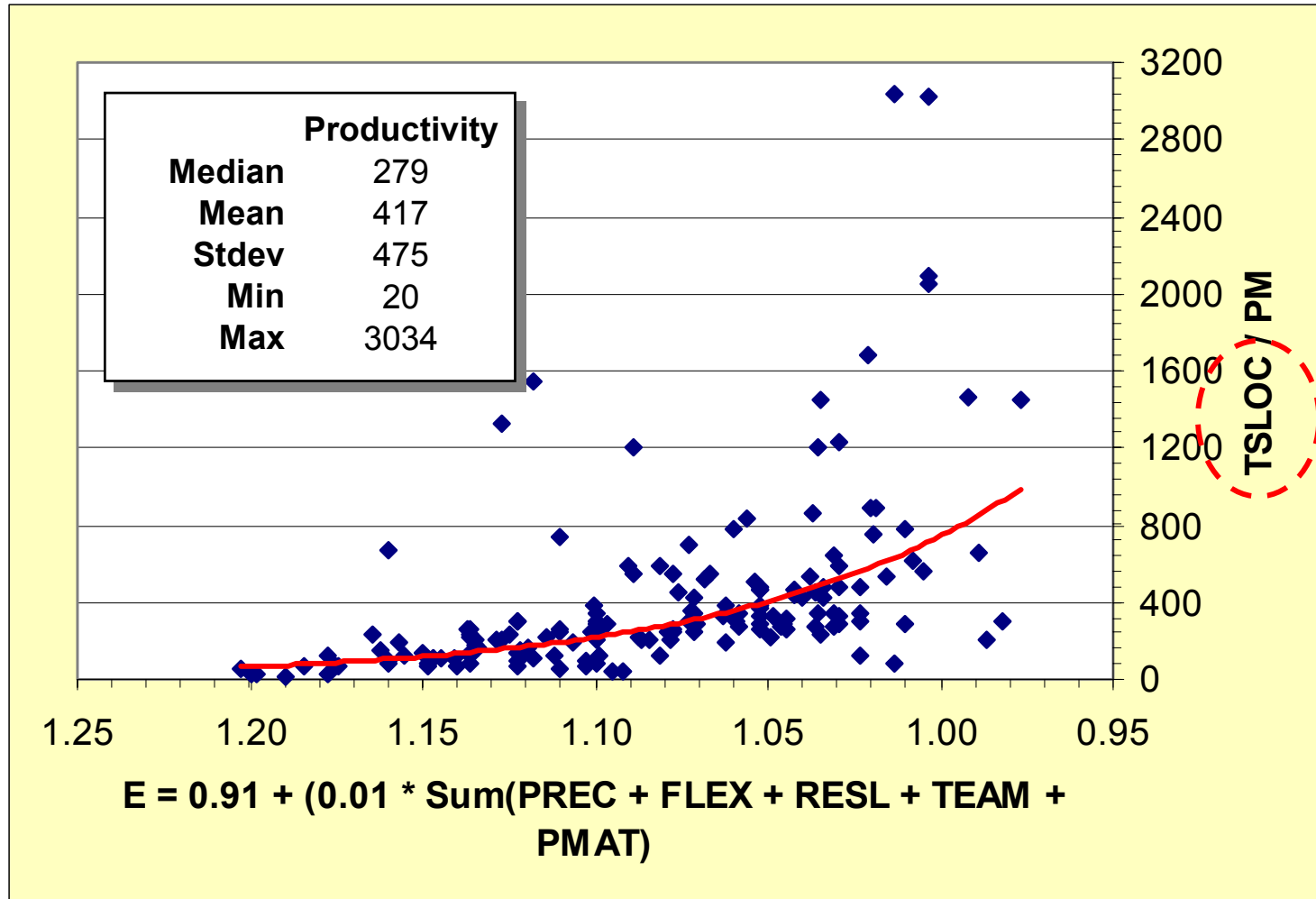
# Productivity Analysis Definitions -1

- Analysis of productivities across all projects used for calibration in the COCOMO Repository
- Size Definitions
  - E: COCOMO II Scale Factors ( $0.91 + 0.01 * (\text{PREC} + \text{FLEX} + \text{RESL} + \text{TEAM} + \text{PMAT})$ )
  - SLOC: size measure expressed as source lines of code for each project
  - TSLOC: new SLOC + adapted SLOC (with no adjustments)
  - Size: new SLOC + adapted SLOC adjusted with reuse model (ESLOC)
  - Size': Size adjusted for the COCOMO II scale constant
    - $(\text{Size})^{0.91}$

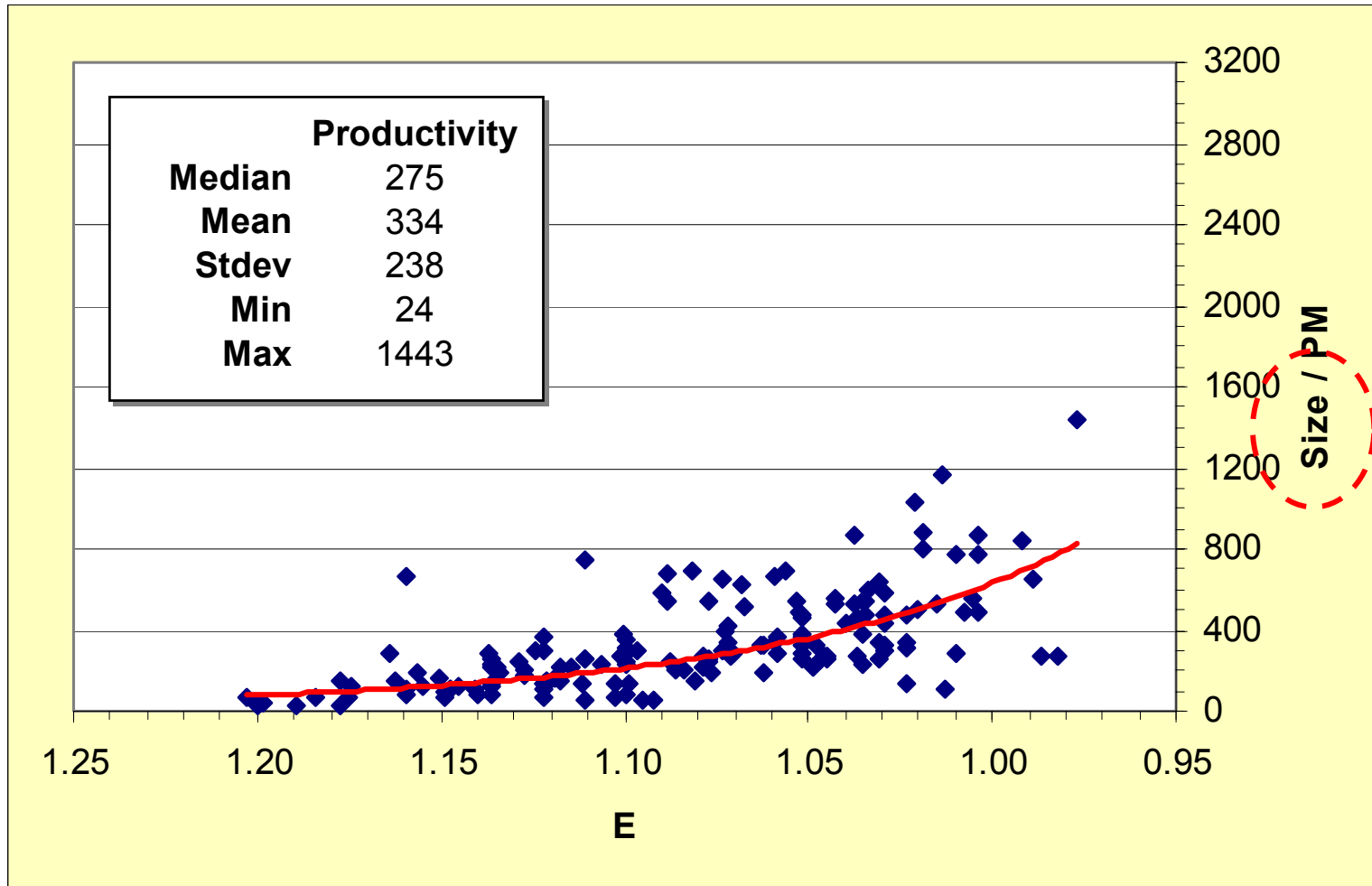
# Productivity Analysis Definitions -2

- Effort Definitions
  - PM: completed project effort expressed as Person Months
  - PM': PM adjusted with COCOMO II cost drivers
    - $(PM) / (\text{Product of all Cost Drivers})$
  - PM'': PM adjusted with COCOMO II cost and scale drivers (B)
    - $(PM) / (\text{Product of all Cost and Scale Drivers})$

# Productivity Analysis -1



# Productivity Analysis -2



# COCOMO II Reuse Model

$$ESLOC = \frac{ASLOC [AA + AAF(1 + 0.02(SU)(UNFM))]}{100} \quad AAF \leq 0.5$$

$$ESLOC = \frac{ASLOC [AA + AAF + (SU)(UNFM)]}{100} \quad AAF > 0.5$$

Where:  $AAF = 0.4 (DM) + 0.3 (CM) + 0.3 (IM)$

$SU =$  Software Understanding

(zero when  $DM = 0$  &  $CM = 0$ )

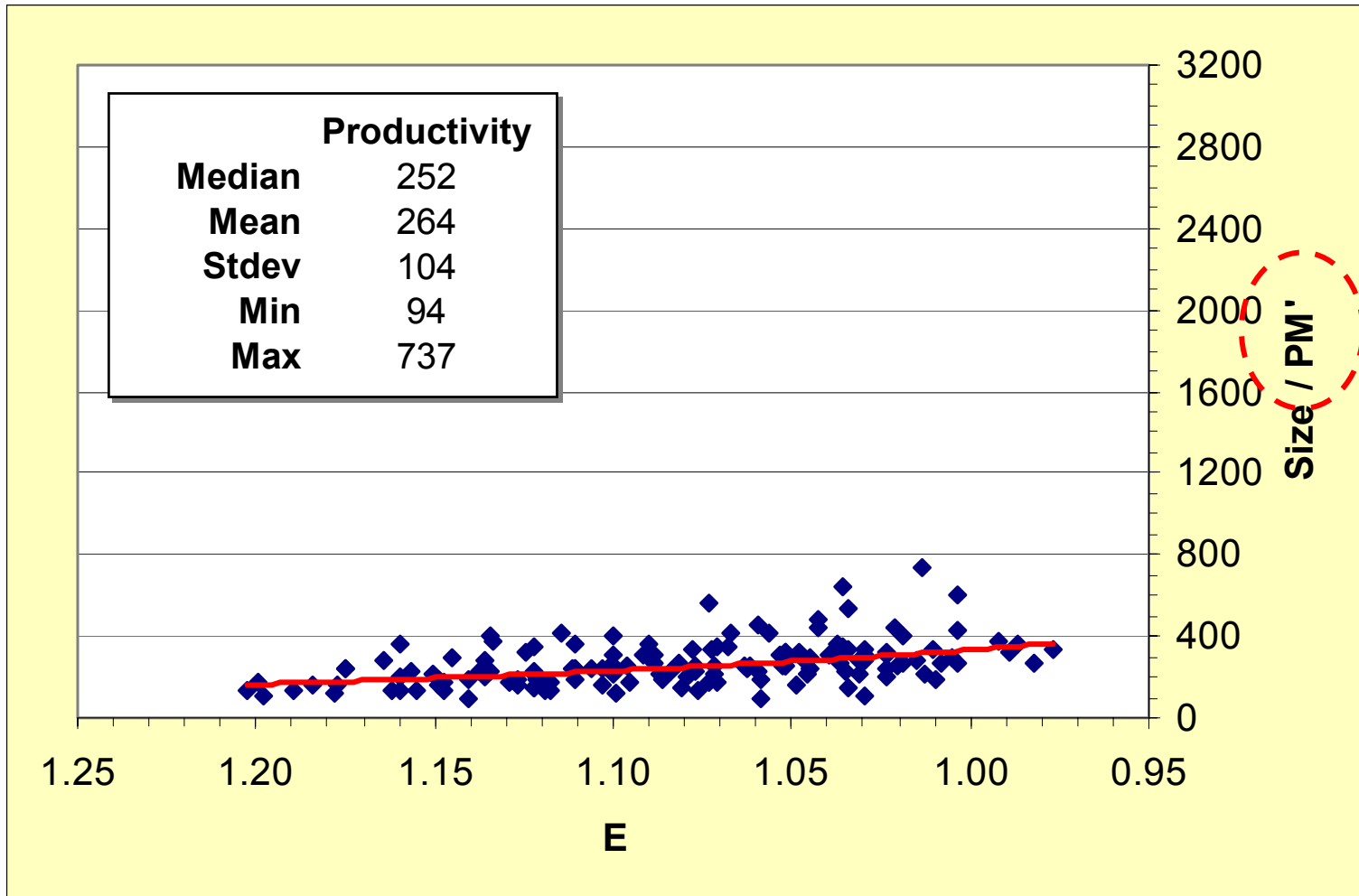
$UNFM =$  Programmer Unfamiliarity

$AA =$  Assessment and Assimilation

$ASLOC =$  Adapted SLOC

$ESLOC =$  Equivalent new SLOC

# Productivity Analysis -3

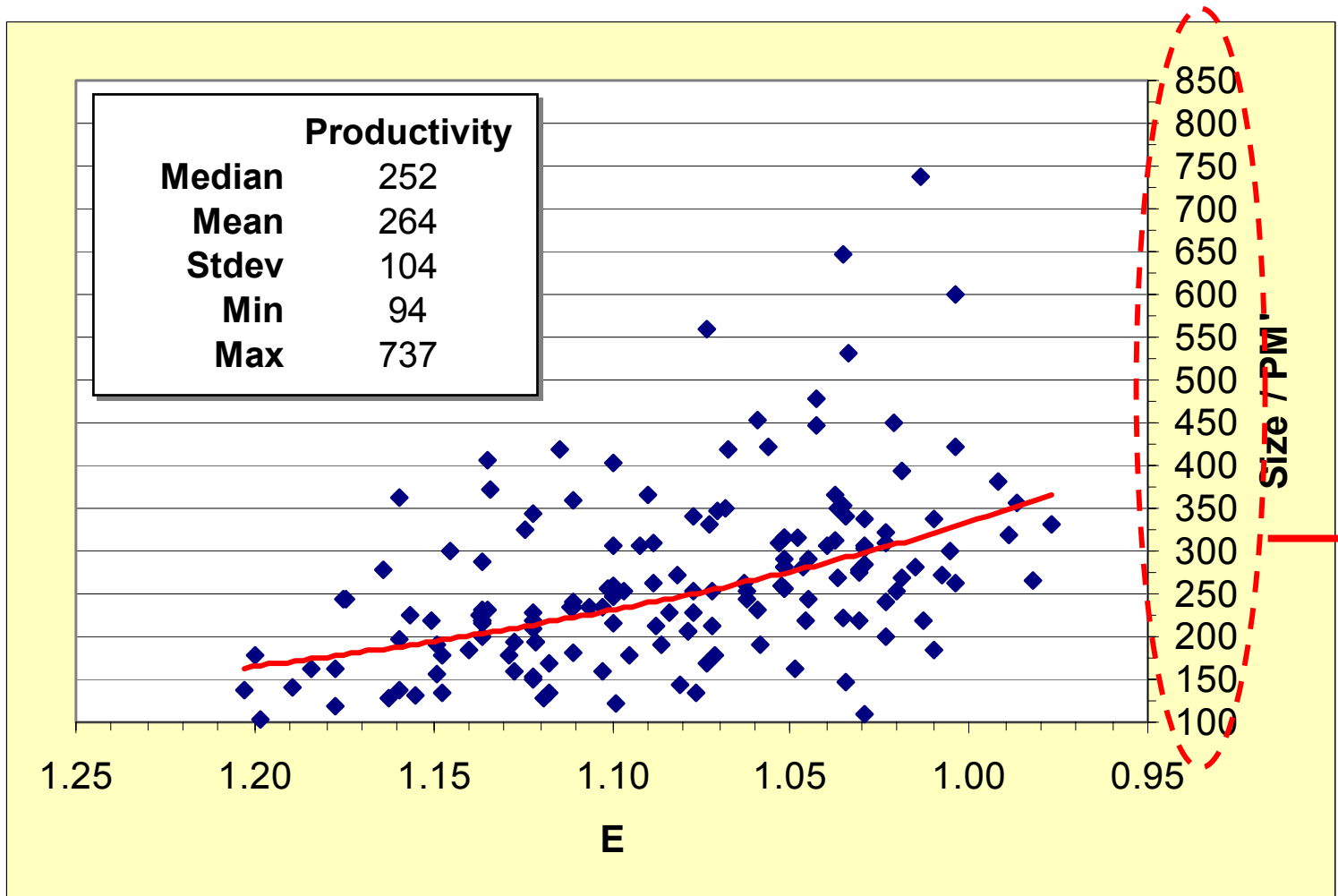


# Adjusting Effort for Cost Drivers

- **Required Software Reliability (RELY)**
- **Database Size (DATA)**
- **Product Complexity (CPLX)**
- **Developed for Reusability (RUSE)**
- **Documentation Match (DOCU)**
- **Execution Time Constraint (TIME)**
- **Main Storage Constraint (STOR)**
- **Platform Volatility (PVOL)**
- **Analyst Capability (ACAP)**
- **Programmer Capability (PCAP)**
- **Personnel Continuity (PCON)**
- **Applications Experience (APEX)**
- **Language and Tool Experience (LTEX)**
- **Platform Experience (PLEX)**
- **Use of Software Tools (TOOL)**
- **Multi-site Development (SITE)**
- **Required Development Schedule (SITE)**

$$PM' = PM / \text{Product}(\text{All Cost Driver Rating Values})$$

# Productivity Analysis -3



# Adjusting for Cost and Scale Factors

## Cost Drivers + Scale Drivers

**Precedentedness (PREC)**

**Development Flexibility (FLEX)**

**Architecture and Risk Resolution (RESL)**

**Team Cohesion (TEAM)**

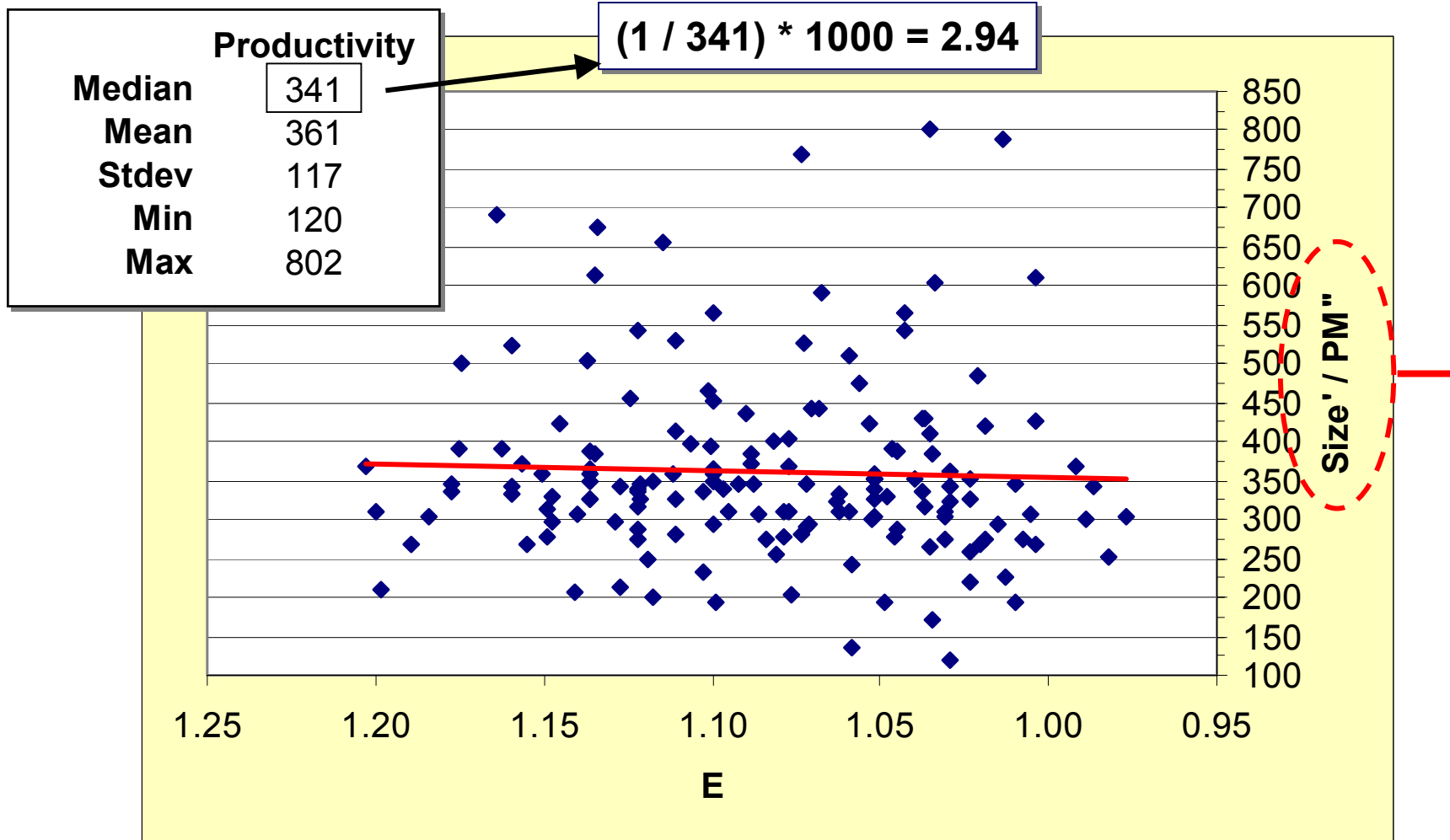
**Process Maturity (PMAT)**

Effort Adjustment Factors = Product(All Cost Driver Rating Values )  
Scale Factor Influence = Product(Size<sup>0.01\*PREC</sup> + Size<sup>0.01\*FLEX</sup> + ...)

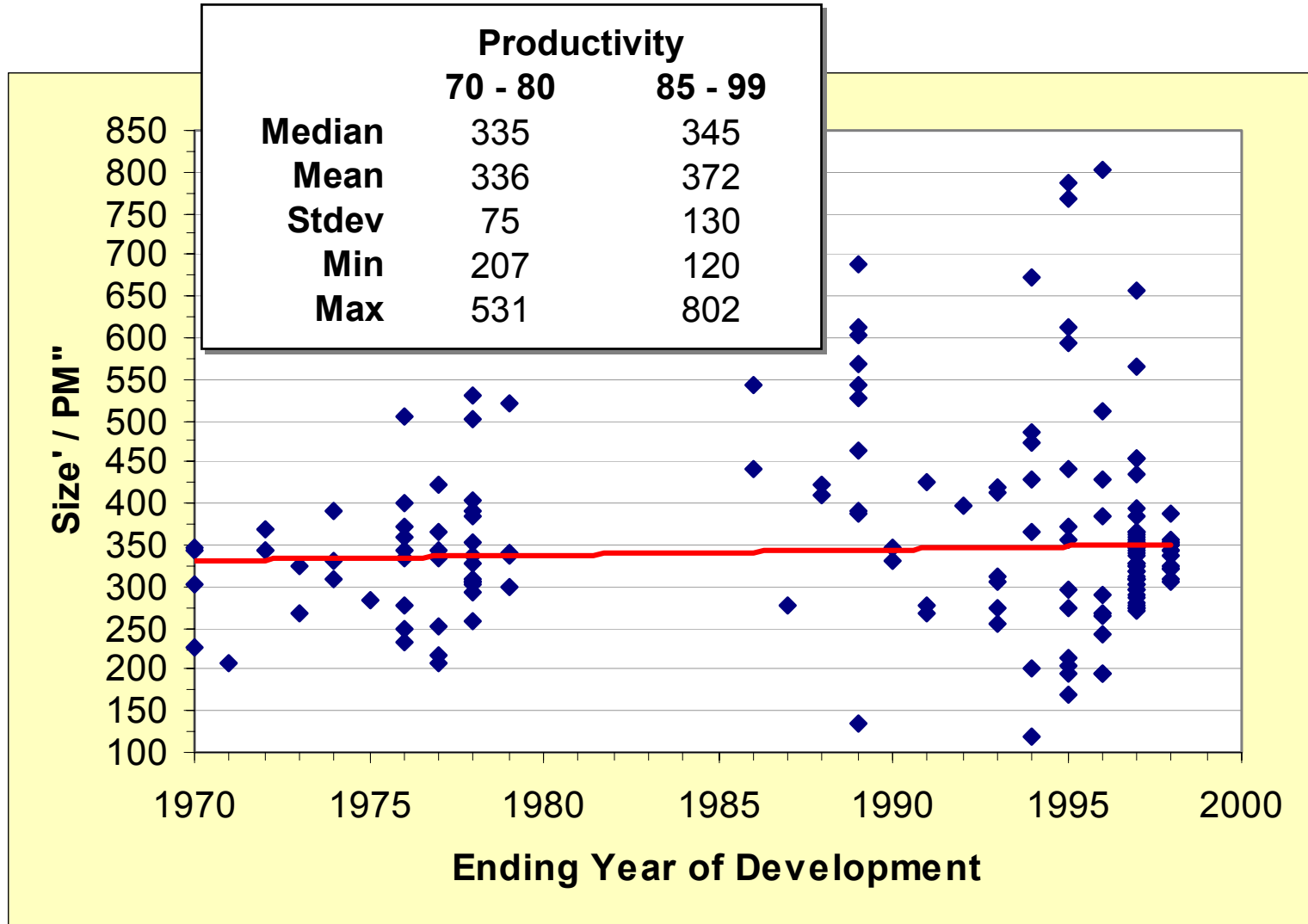
PM'' = PM / Effort Adjustment Factors \* Scale Factor Influence

Size' = Size<sup>0.91</sup>

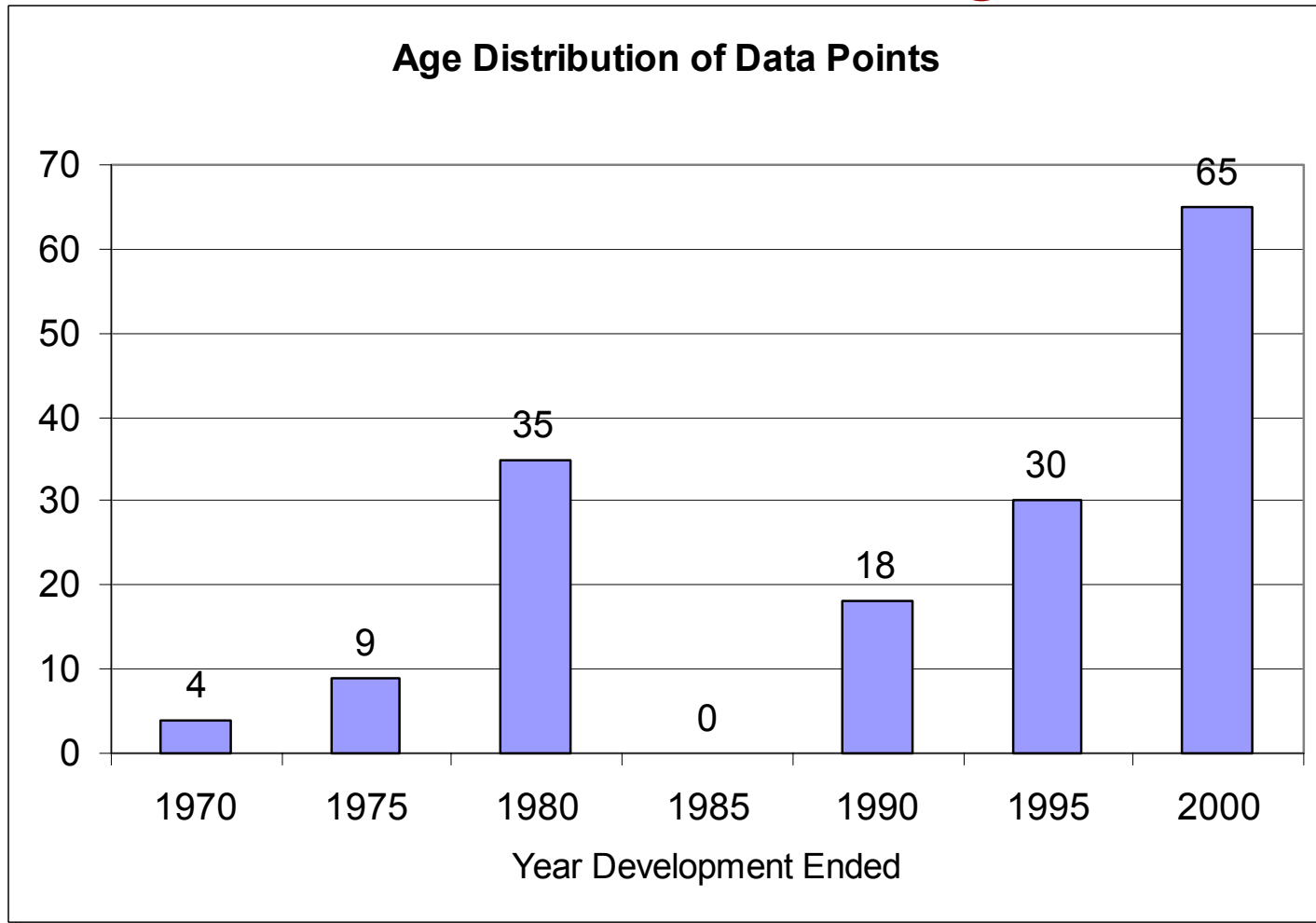
# Productivity Analysis -4



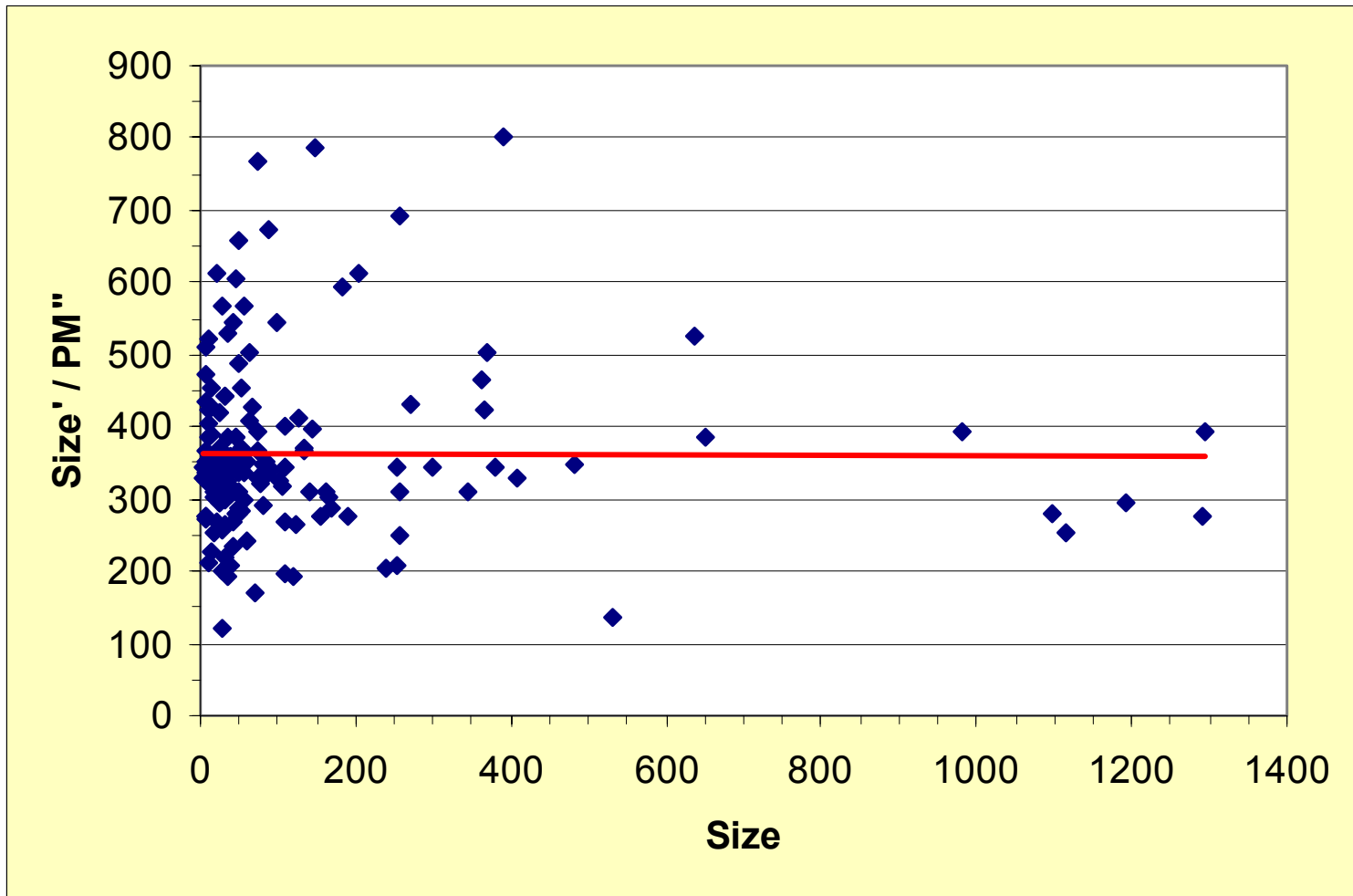
# COCOMO II Data Age -1



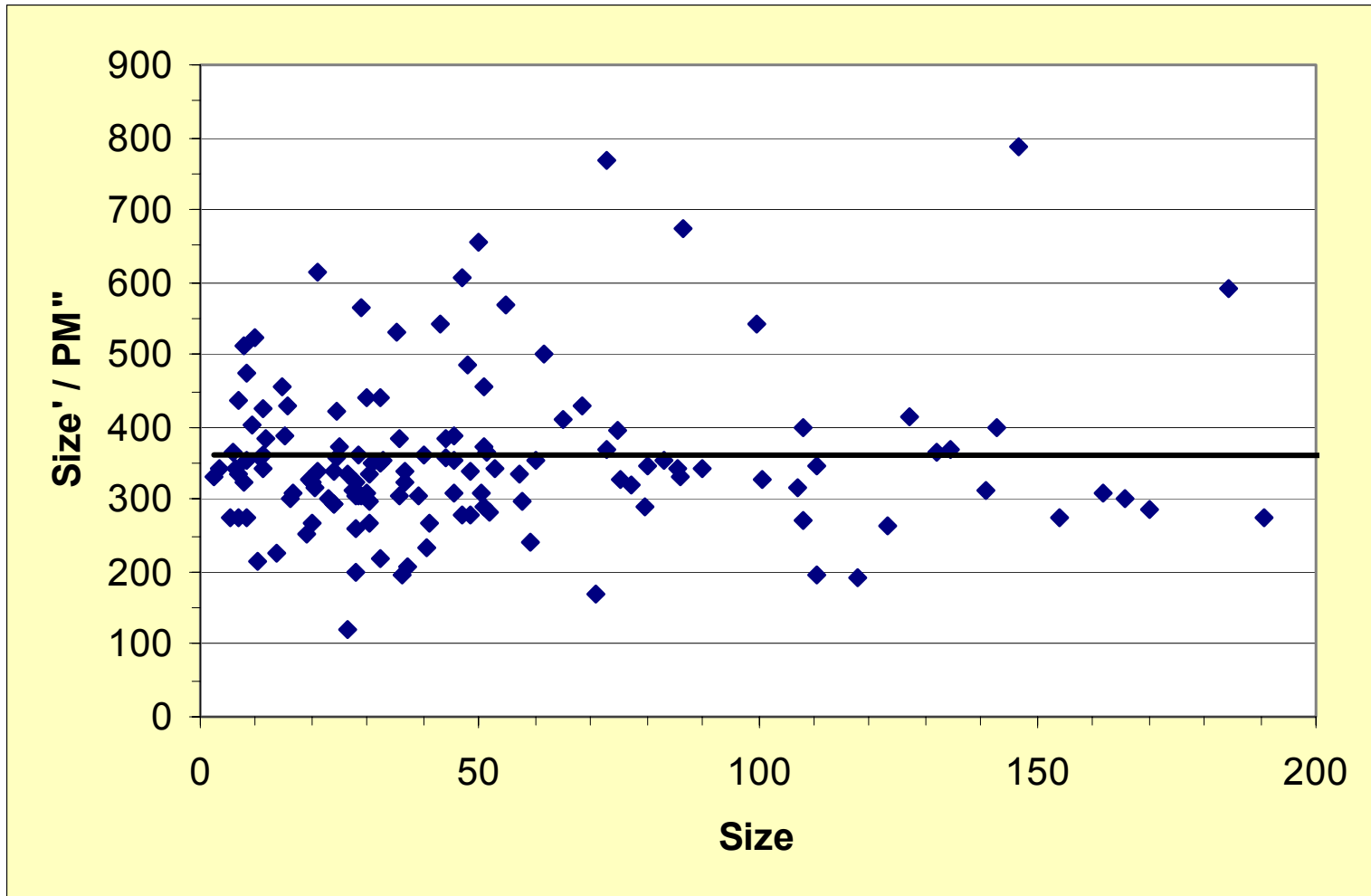
# COCOMO II Data Age -2



# Data Size versus Productivity -1



# Data Size versus Productivity -2





# Outline

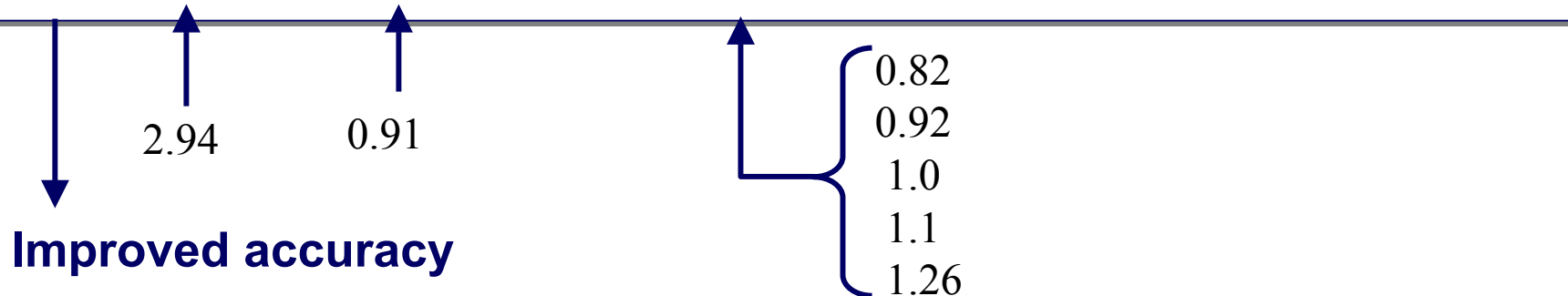
- Characteristics of the current COCOMO II calibration data
- • Status of the 2003 model calibration

# Objective

- Derive numerical adjustments for each of COCOMO II driver's rating level.
- Derive new multiplicative (A) and scaling (B) constants

PREC \* FLEX \* RESL \* TEAM \* PMAT

PM = A \* Size<sup>(B+0.01ΣSF)</sup> \* RELY \* CPLX \* DATA \* ... \* SCED





# Data Collection and Storage

- Data Collection
  - Paper collection form (most desirable because of detail)
  - From the USC COCOMO software tool estimation files
- Historical - whole project
- New data entered into a separate database from calibration data and evaluated.
- Data storage
  - Data is labeled with generic identifier
  - Stored in locked room
  - Access limited to 3 researchers



# New Data for Calibration

- Quality of data impacts the quality of the model
- Collected data has challenges
  - Level of detail
  - Consistency (project size, scope, units, ratings)
  - Violation of known relationships
- Currently screening data for incorporation into calibration database
  - 35 project data points have been qualified for inclusion into the repository
- Affiliate Organizations provide the majority of data



## 2002 Calibration Data Status

- Had planned to release calibration results during the 17th COCOMO/SCE Forum (Fall 2002)
- We need more project data
  - If you calibrate the COCOMO II model locally - would you consider letting us use your data to calibrate the scale / cost drivers?
  - If you have recently completed projects, would you consider filling out one of our data questionnaires? We can conduct a data collection interview over the phone.



# Calibration Handbook

- Every college coach faces this problem:
  - Your players will eventually graduate
- Documenting the procedures for calibrating COCOMO II (coach's playbook)
  - Storing and retrieving repository data
  - Performing linear regression
  - Performing Bayesian calibration using prior information
  - Model performance analysis



## For More Information

- E-mail: [cocomo-info@sunset.usc.edu](mailto:cocomo-info@sunset.usc.edu)  
[Brad@Software-Metrics.com](mailto:Brad@Software-Metrics.com)
- Website
  - <http://sunset.usc.edu/research/COCOMOII/index.html>
  - Software for COCOMO II and COCOMO 81 models
  - Data collection form
  - Upcoming COCOMO events (Forum in Oct 2002)