Does Project Performance Stability Exist?
A Re-examination of CPI and
Examination of SPI(t) Stability

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* The contents of this presentation are the presenter's personal views and conclusions which do not reflect an endorsed position of the PMI-CPM.

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Agenda

- **Overview of Research**
  - Summary of CPI Stability Research post A-12 cancellation
  - Brief Overview of Earned Schedule Method
  - Overview of Latest xPI Stability Research Project
  - The Results & NAVAIR corroboration
  - Additional Analysis
  - Conclusions, Consequences & Suggested Way Forward
  - Other Issues
  - Other Issues – Abba Criticisms

- **Workshop Discussion**
  - Questions, Observations, Criticisms, Alternate viewpoints
  - Suggestions on possible ways forward to resolution
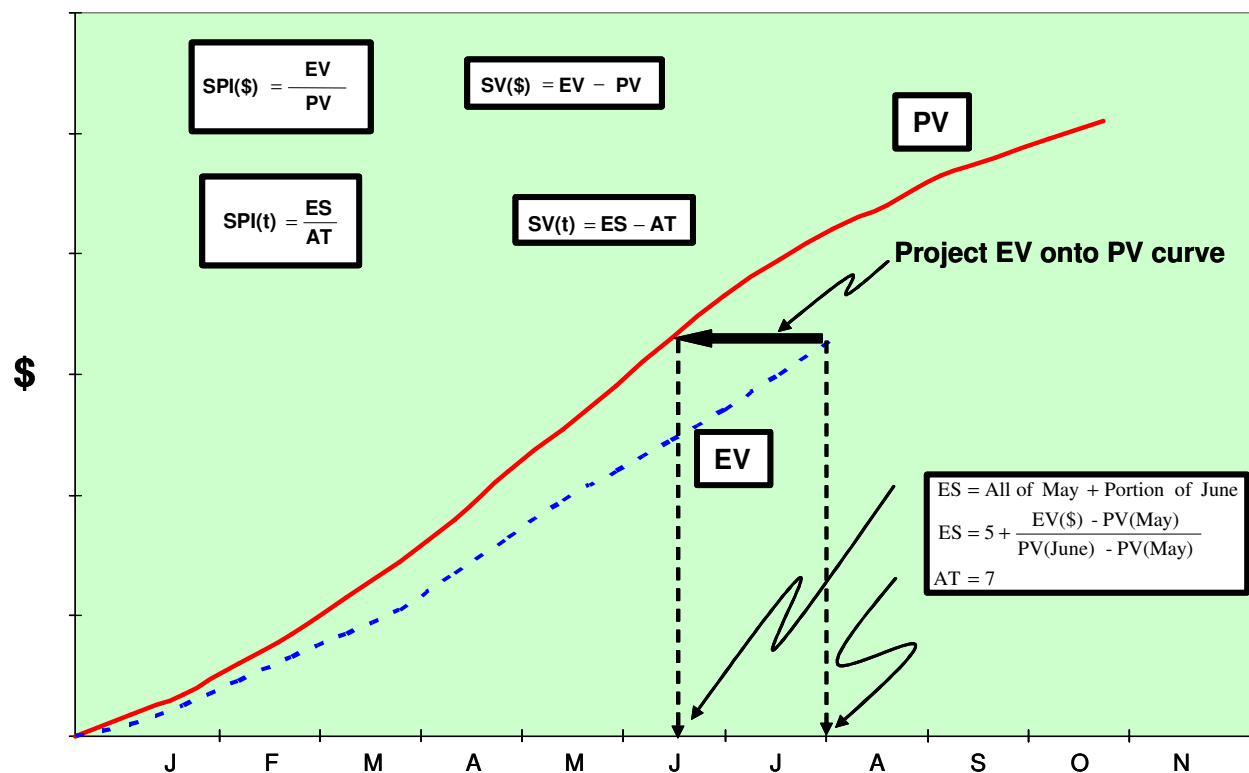
- **Action Plan**

Summary of Research Post A-12 Cancellation

- Research by Dr. David Christensen and associates
  - CPI cum (CPI) stabilises by 20% of project completion
  - Stability usually defined to mean CPI at completion does not change by more than +/- .10 from CPI $_{20\%}$
    - Initial stability research published in 1992 using data from 26 completed Air Force programs from USAF Systems Command Aeronautical Systems
    - Subsequent research used program data from US DoD DAES database (Christensen & Heise: 1993)
- CPI stability findings since generalised as being universally applicable "to all projects using Earned Value"
  - Fleming and Koppelmann

Earned Schedule Brief Summary
Concept developed by Lipke in 2003

- <u>Time</u> based schedule performance metrics using EVM data
  - SV(t) and SPI(t) behaviour analogous to the EVM cost metrics
- ES metrics do not fail – work for early and late finish projects
  - Revert to unity at completion only if on time schedule performance ACTUALLY achieved

$$SPI(\$) = \frac{EV}{PV}$$

$$SV(\$) = EV - PV$$

PV

$$SPI(t) = \frac{ES}{AT}$$

$$SV(t) = ES - AT$$

Project EV onto PV curve

EV

$$ES = \text{All of May} + \text{Portion of June}$$

$$ES = 5 + \frac{EV(\$) - PV(May)}{PV(June) - PV(May)}$$

$$AT = 7$$

$

J   F   M   A   M   J   J   A   S   O   N

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The Research Project

- Aim:
  - Re-examine CPI stability and
  - Compare the stability behavior of SPI(t) with CPI *to ascertain whether SPI(t) exhibited similar stability characteristics* to those extensively reported for CPI
- The Data:
  - 3 disparate commercial sector EVM data samples utilized

Source	CPI Sample	SPI(t) Sample
UK Construction	10	20
Israeli Hi Tech	12	12
Australian IT	4	5
Composite	26	37

  - The data was "scrubbed" – Re-baselined projects were excluded

The Results

- Formal hypothesis testing
  - Sign Test at 0.05 level of significance

    "none of the null hypotheses can be rejected, for any of the three samples as well as the composite of all samples.
    This means that stability was not achieved for either CPI or the SPI(t) by the time the project was 20 percent complete."

	CPI Stability		SPI(t) Stability	
	Test Statistic	Test Result	Test Statistic	Test Result
UK Construction	0.623	Ho	0.748	Ho
Australian IT	1.000	Ho	0.500	Ho
Israeli Hi-Tech	0.806	Ho	0.613	Ho
Composite	0.916	Ho	0.629	Ho

Table 1: *Hypothesis Test Results*

- Summary of Raw Data

Stability Achieved		UK Construction	Australian IT	Israeli Hi-Tech	Composite
SPI(t) cum.	≤ 20%	3	0	1	4
> 20%		17	5	11	33
CPI cum.	≤ 20%	2	0	1	3
> 20%		8	4	11	23

Table 2: *Summary of Stability Achievement Related to 20 Percent Completion*

The (Lack of) CPI Stability Corroboration

- NAVAIR research by Michael Popp, mid 1990s
  - Data from same source used by Christensen
    - Known thanks to correction to paper by Mr. Wayne Abba
  - Popp sought to determine
    - "Given a program has a CPI of X and a percent complete of Y, what is the most likely finishing CPI"?
- Popp did **not** focus on CPI stability
  - But plotted relationships between CPI cum <u>Final</u> and CPI cum <u>Current</u> in each 10 percentile band
- Popp report now in public domain (with permission)
  - PMI Sydney Chapter website

The Correlation Plot: CPI Final and CPI 10-20%

All

CORRELATION BETWEEN CUMULATIVE CPI
AT 10-20% COMPLETE AND FINAL CPI

FNLCPI.XLS   Chart 10-20
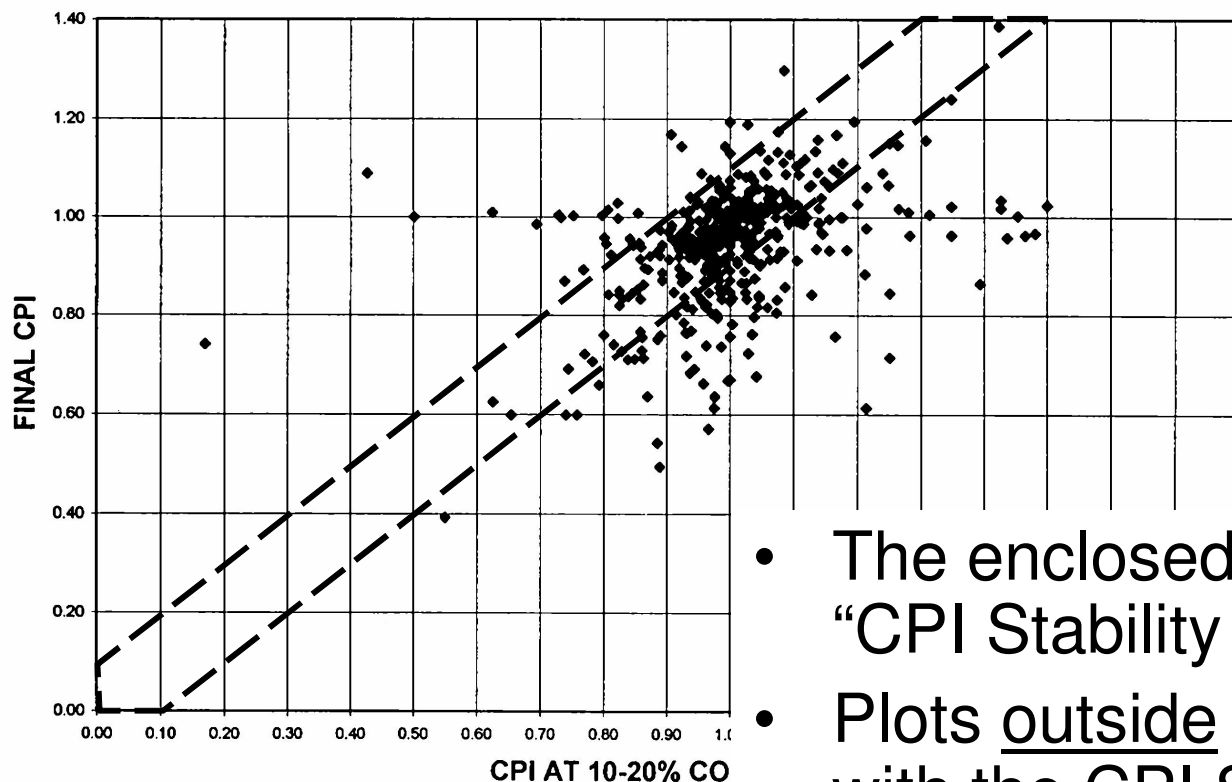
- The enclosed area bounds where the "CPI Stability rule" applies
- Plots outside bound area **conflict** with the CPI Stability rule

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Additional Analysis

- Commercial sector data
  - Within each 10% complete percentile band projects were categorized as follows:
- Cost at Completion:
  - Under or On Budget (UOB)
  - Over Budget (OvB)
- Schedule at Completion:
  - Early or On Time finish (EOT)
  - Late Finish (LF)
- Purpose:
  - To determine whether achieving earlier stability correlated to improved cost and schedule outcomes at completion
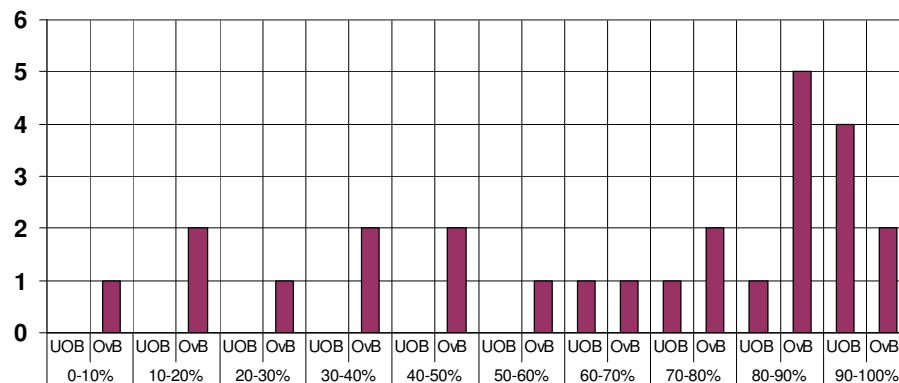
The Results

"… achievement of earlier stability is not correlated with improved final cost and/or schedule outcomes"

- For UOB and EOT projects where cost and schedule stability was achieved late … achieving earlier stability would have been disadvantageous … to the final outcome(s) … **because project performance progressively improved over the life of those projects.**
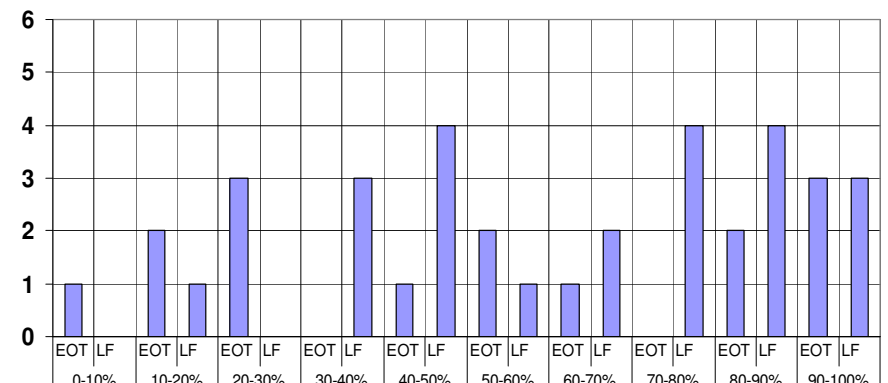

Project Completion Categories by CPI Stability Bands (3 Data Samples Aggregated)

	UOB OvB 0-10%		UOB OvB 10-20%		UOB OvB 20-30%		UOB OvB 30-40%		UOB OvB 40-50%		UOB OvB 50-60%		UOB OvB 60-70%		UOB OvB 70-80%		UOB OvB 80-90%		UOB OvB 90-100%	
Israeli HI Tech				1		1		2		2		1				2		3		
Australian IT																	1	2	1	
UK Construction		1		1							1	1	1		1	1	2	1	
Totals		1		2		1		2		2		1	1	1	1	2	1	5	4	2

Project Completion Categories by SPI(t) Stability Bands (3 Data Samples Aggregated)

	EOT LF 0-10%		EOT LF 10-20%		EOT LF 20-30%		EOT LF 30-40%		EOT LF 40-50%		EOT LF 50-60%		EOT LF 60-70%		EOT LF 70-80%		EOT LF 80-90%		EOT LF 90-100%	
Israeli HI Tech				1	1			2		2		1				3			1	1
Australian IT								1				1					2	1		
UK Construction	1		2		2			1	2	2			2		1		3	2	2	
Totals	1		2	1	3			3	1	4	2	1	1	2		4	2	4	3	3

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The Conclusions

- The widely reported CPI stability rule cannot be generalized to "all projects using Earned Value"
  - Claiming the rule had <u>unqualified</u> universal applicability to "all projects using Earned Value" an unfortunate overstatement
- CPI stability rule cannot be generalized even within US DoD
- Based on commercial sector EVM data analysis
  - **Achieving early stability is not necessarily "good"**
  - **Achieving late stability is not necessarily "bad"**
- Where projects have not exhibited "CPI stability"
  - EVM practitioners can now know that this is neither unique,
  - Nor is it necessarily an adverse reflection on … those projects
- **The consistent behavior to CPI demonstrated by SPI(t) provides further support for the validity of SPI(t) metric and ES method**

The Consequences

Thanks Kym,

"I think it is traditional to burn heretics at the stake and then accept their findings as true after an appropriate delay of several years or decades – there were a few notable exceptions, Galileo spring to mind, he merely was placed under house arrest ….. I look forward to seeing how you go.

The paper certainly makes sense and is a great piece of research."

E-mail dated 6 May 08 from Patrick Weaver, Director Mosaic Project Services Pty Ltd, Melbourne Australia

The Way Forward

- Those interested should read the paper, supporting materials and make up their own minds

- More research is needed to determine whether there are project performance characteristics:
  - Which result in early CPI stability (i.e. the rule applies)
  - **Where early CPI stability was not achieved due to progressively improving CPI performance**

- Academic research aimed at establishing a theoretical rationale for project performance instability

- Researchers repeating the current research using different data samples
  - Lipke's Stability Point Calculator is in the public domain

- ***Test for xPI stability on your own completed projects***

Other Issues

- CPI Stability Rule has been inconsistently expressed
  - Christensen et. al.
    - Stability usually defined to mean CPI at completion does not change by more than +/- **.10** from CPI 20%
  - Fleming and Koppelmann
    - "remaining performance will not likely change by more than plus or minus **10%** at the point of project completion."
- Is it the change an <u>absolute</u> (+/- .10) value or <u>relative</u> (+/-10%) value?
  - It is important!
- (Research and Paper relied in the Christensen definition)

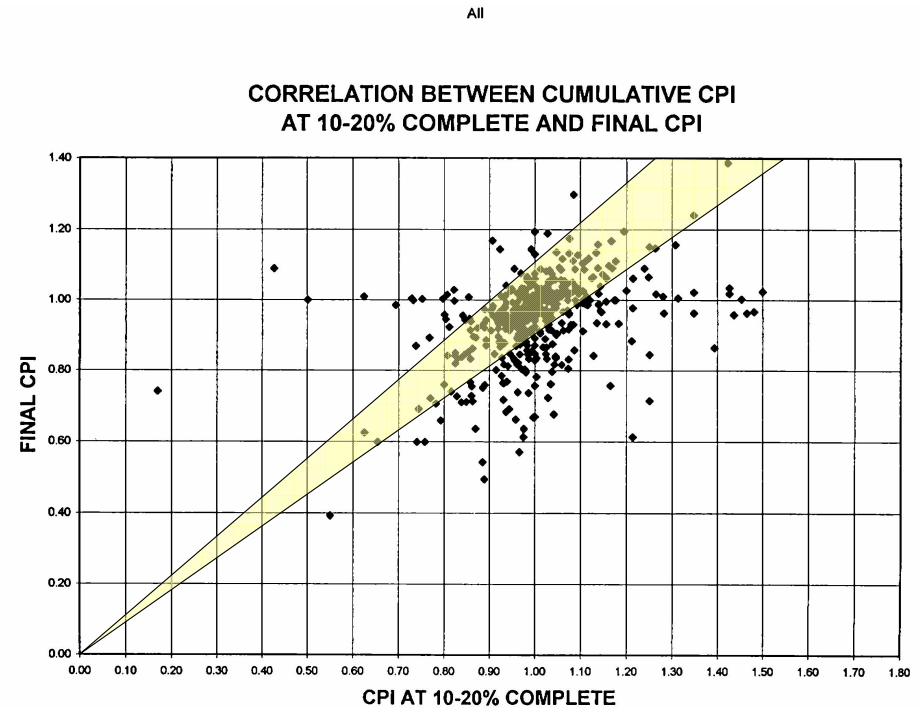# Using a "Popp" Plot to Illustrate

- The area bound by the CPI @ 20% Stability rule differs
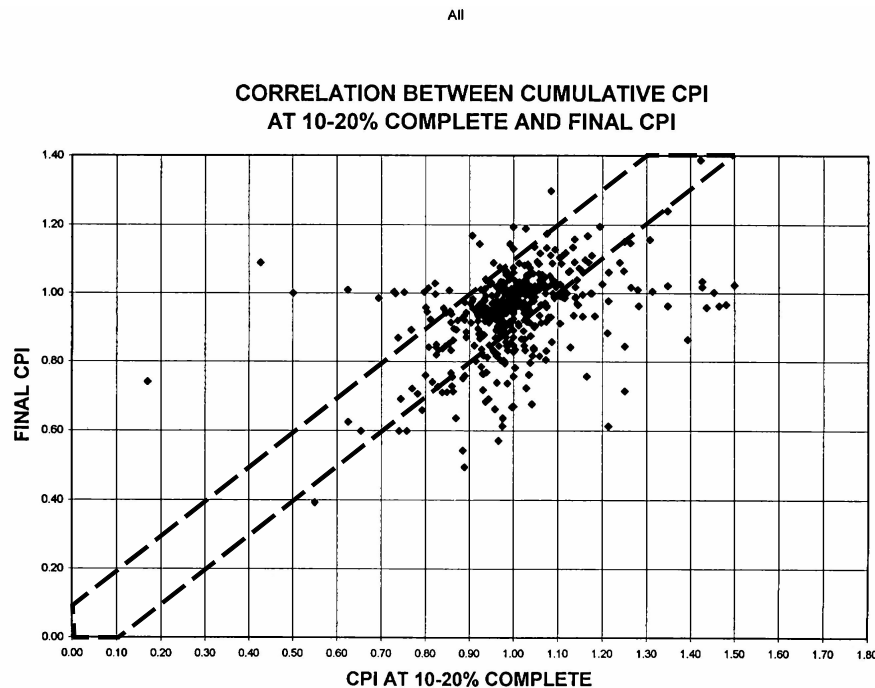
Christensen et al
Absolute Value: +/- .10

Fleming & Koppelmann:
Relative Value: +/- 10%

Other Issues: What the Paper Did Not Say

- Has <u>not</u> said that the CPI stability rule NEVER applies
  - Very clear from Christensen's research and "Popp" NAVAIR data there are MANY occasions in US DoD where the rule clearly applies
- Further research recommended aimed at examining the performance characteristics of projects where:
  - The CPI stability rule does seem applicable to determine whether there are project characteristics which result in early CPI stability
  - Progressively improving CPI precluded early stability

Other Issues: Lipke Hypothesis

- Walt Lipke (non-controversial) paper in the MN in 2005
  **A Re-Examination of Project Outcome Prediction ....
  using Earned Value Management Methods** [*]:

  – Actually questioned the universal applicability of the CPI stability rule and started looking at this issue

- Lipke's hypothesis in summary:
  Where CPI stability rule hold true is likely a function of
  - (Very large) scale and
  - Very long duration of the projects examined
    as typified by major US DoD acquisition programs

- Paper's findings using smaller scale commercial sector EV projects consistent with Lipke hypothesis

  – But not confirmatory of it

Other Issues: EVM Credibility

- How does making of "authoritative" statements that
  - The CPI stability rule has universal applicability "to all projects using Earned Value"
  - Which practitioners may not always observe in practice
  - **Enhance the credibility of the EVM method?**

Other Issues: Erroneous Decisions

- To the extent that the CPI stability rule is used to assist management decision making
  - The risk is that management decisions made in reliance of the CPI stability rule applying may be erroneous or flawed in circumstances where the rule may not apply

- The "good news"
  - It may be possible to improve project performance from the 20% completion point ….
  - Further research is recommended

Other Issues: Abba Criticisms

`I suggest that these disparate projects did not implement EVM consistently, as on DoD contracts, and that the analysis lacks rigor (Israeli data were analyzed "using visual inspection of charts").`

- Response:
  - Sample data was heavily analyzed and data integrity issues considered at length
  - **Concluded was that the data was credible** Could think of no valid reason that would invalidate the data from organizations **voluntarily** implementing EVM
    - Particularly as the data showed that most projects in the samples finished over budget and behind schedule!
  - The "visual inspection of charts" Abba refers to
    - Relates to a prior paper of Zwickael et. al. published in Project Management Journal in 2000

Other Issues: Abba Criticisms

- Similar questions of the "rigor" of US DoD implementation of EVM (at oversight level) can be raised

- Reason for cancellation of the Earned Schedule (ES) research using DAES data by AFIT student in 2004

  Results: The historical data collection procedures for the DOD and USAF do not allow for sufficient testing of ES theory at this time. ... In order for the ES Theory to be fully investigated, additional data must be collected. This research shows that the necessary data may also not be available despite the best collection efforts. The original schedule and planned duration information is critical to successful evaluation of the ES methodology. [17]

- The "original schedule and planned duration information"
  - **Should be available from the Performance Measurement Baseline ….**

Other Issues: Abba Criticisms

"Henderson and Zwikael do not explain how Popp selected contracts from the same source"

- Popp report now public domain on PMI Sydney Chapter website

- Data selection
  - Henderson and Zwikael – Re-baselined projects excluded
    - All projects included unless data issues justified exclusion
  - Christensen and Heise: 1993 included 155 "contracts"
    - 109 with "stable" Baselines
    - 46 with unstable Baselines

    "Although the sampling technique was purely judgmental, the number and variety of programs, contract types, and contract phases are considered sufficiently large to establish generalizability" *

Other Issues: Abba Criticisms

- Data selection
  - Popp
    - Over 350 programs in sample (Development and Production)

For a number of programs, the Total Allocated Budget changed early in the program.

This of course will affect the percent complete for the CPI values being studied. In cases

where the TABUDG changed, the changes usually occurred early in the program and was

insignificant when compared with the total program cost. Projects that have significant

changes in the TABUDG over their life may not be able to utilize the techniques *

developed in this study.

- Was Christensen's subjective selection criteria inadvertently biased?

Additional Review Following Abba Criticisms

- Christensen & Heise: 1993 (Conclusion)

  "Based on an analysis of 155 contracts from the DAES database, the cumulative CPI was stable from the 20 percent completion point _with a 95 percent confidence interval_. Stability was defined in terms of CPI range being less than 0.200." (_emphasis added_)*

Additional Review Following Abba Criticisms

- Yet Table 3 of the paper states that only **86%** of the contracts had a stable CPI at 20% Complete!
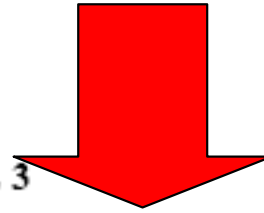 - 134 of 155 total contracts

TABLE 3
Cumulative CPI Range Stability

Percent complete:	0%	10%	20%	30%	40%	50%
Total contracts	110	152	155	155	155	155
Contracts w/ stable CPI	59	116	134	141	150	153
Percent stable	54%	76%	86%	91%	97%	99%
Maximum range	1.243	0.644	0.434	0.364	0.312	0.299
Minimum range	0.017	0.017	0.017	0.007	0.003	0.003
Mean range	0.262	0.145	0.115	0.096	0.081	0.069
Standard deviation	0.213	0.103	0.078	0.068	0.056	0.051
95% confidence interval	±0.040	±0.016	±0.012	±0.011	±0.009	±0.008

Additional Review Following Abba Criticisms

- Conclusions
  - Subsequent claims of the universal applicability of the CPI Stability Rule to "all projects using EVM"
    - **Not even supported by the seminal paper which claimed "generalizability"!**
    - The seminal research paper used US DoD data!
  - We cannot explain the issue of
    - The raw data showing stability only being achieved by 86% of the projects and the paper's conclusion:

      `CPI was stable from the 20 percent completion point` *`with a 95 percent confidence interval`*
- "95% Confidence Interval" qualifier omitted in subsequent papers and books repeating the claim

What About Earned Schedule?

- Paper demonstrates that using Earned Schedule, research opportunities are equally applicable to project schedule performance
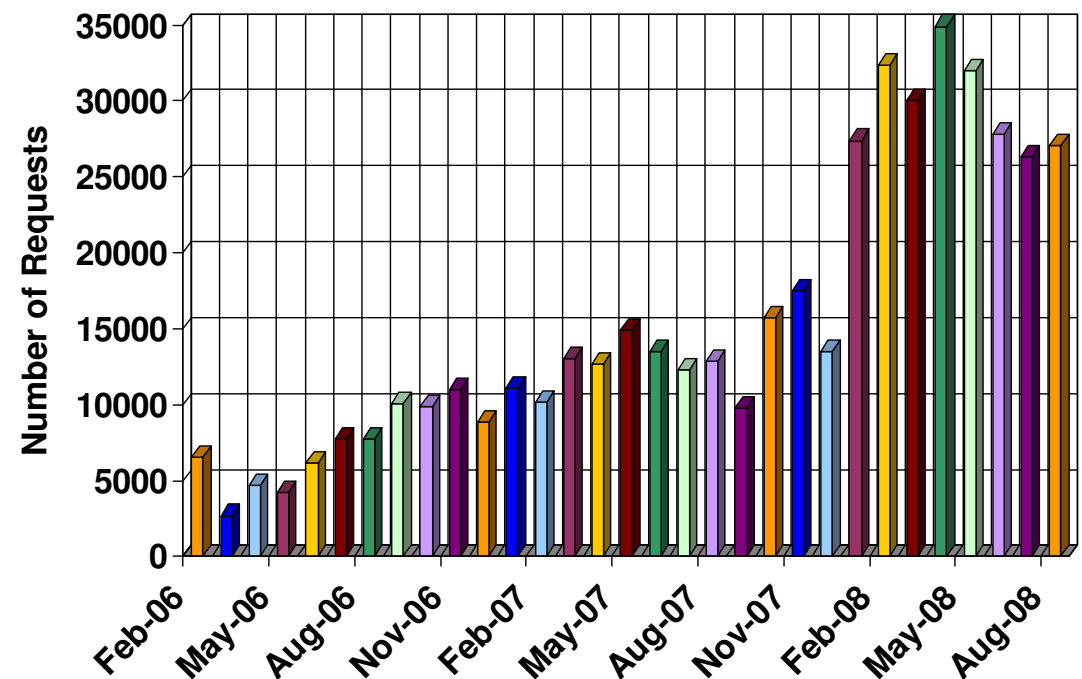
- Opinion on Earned Schedule varies:
  - **Particularly amongst EVM "thought leadership"**

- Website metrics
  - **> 25,000 hits per months since Feb 08**
    - **> 30,000 hits per month from Feb to May 2008**
  - **> 20 <u>GB</u> data downloaded from site since Feb 2006**

ES Website Activity

- **Conclusion**

Earned Schedule has momentum and achieved its place in the project management domain

Information Sources

- Earned Schedule Website
  http://www.earnedschedule.com

- PMI Sydney Chapter Website
  http://sydney.pmichapters-australia.org.au/
  Click "Education," then "Presentations and Papers" for .pdf copies

- **Crosstalk (online version of paper)**
  http://www.stsc.hill.af.mil/crosstalk/2008/04/

Calculators and Analysis Tools

http://www.earnedschedule.com/Calculator.shtml

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- **Feedback requested**
  - Improvement / Enhancement suggestions
  - Your assessment of value to Project Managers
  - Disclosure of application and results
    - (with organization permission and/or anonymously)
  - Application assistance if needed (upon email request)

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