Globally Distributed Software Development Project Performance: An Empirical Analysis

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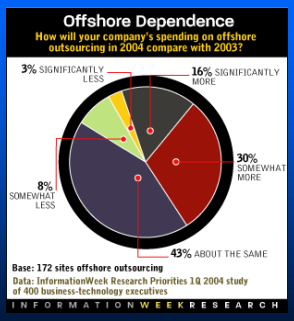
Motivation

- Distributed software development becoming pervasive
  - $ 12.5 billion trade with India
  - $ 5 billion trade with China
  - $ 475 million trade with Russia
  - Labor shortage
  - Cost difference
  - Strategic regional presence

  (Carmel 1999, Carmel & Agarwal 2002)



Offshore Software Development

- Dispersion in offshore development
  - 'Offshore': Primary development center
  - 'Onsite': Secondary development center
- Lower production costs at offshore
- Significant coordination costs

America's pain, India's gain
Economist Jan 13, 2003

Outsourcing Debate Enters Political Arena
Information Week, Jan 12, 2004

SAP puts its eggs in India basket
Economic Times, August 4, 2004

Microsoft Courts Offshore Outsourcers
Information Week July 23, 2004

Outsourcing Debate Tainted by Myths, Misconceptions
FoxNews, April 22 2004

Outsourcing Debate Driven by Cost, Agility
Computer World Mar 3, 2003

Research Questions

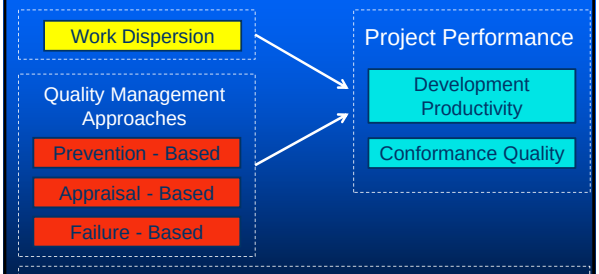
1. What is the effect of dispersion on software project performance?
2. What are the relative efficacies of prevention, appraisal and failure –based quality practices?

Roadmap

- Motivation & Background
- Model of Distributed Software Development
- Data Collection
- Evaluation of Hypothesis
- Conclusion

6

Research Model



Quality Management Approaches

- Categorization of practices
  - Prevention, Appraisal & Failure – based
  - (Nandakumar, et al. 1993, Mendez and Narasimhan 2002)

Prevention - Based	Appraisal - Based	Failure - Based
1. Training • Technical • Business • Process 2. Configuration management 3. Planning & Scheduling	1. Requirement, specification & design peer reviews 2. Code Inspection 3. Status Reviews	1. Unit Testing 2. System Testing 3. Bug tracking and correction 4. Prototyping 5. Intermediate builds

Empirical Models

1. *Development productivity = f {conformance quality, work dispersion, defect prevention, task appraisal, failure costs, reuse, team size, project duration}*

2. *Conformance quality = f {development productivity, work dispersion, defect prevention, task appraisal, failure costs, code coverage, code size, team size, project duration}*

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10

Data Collection & Analysis

- Field Study at a large global software firm
  - Data from 42 projects tracked from start to finish
  - Dispersion between India and USA
  - CMM Level 5 process maturity
  - People Management Level 5 (PCMM)

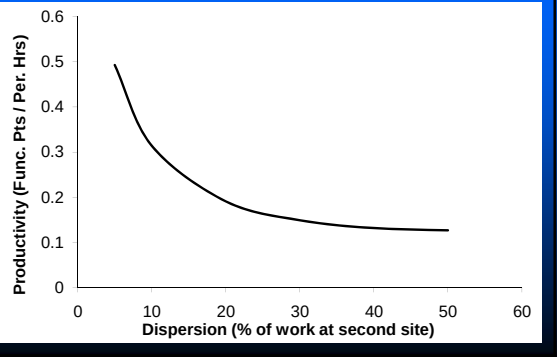
Summary Statistics

Variable	Unit	Mean
Productivity	Func. Pts / Person Hrs	0.26
Quality	1/ (No. defects +1)	0.28
Dispersion	Unit less measure	4220.58
Prevention QMA	% of total project hrs	4.57
Appraisal QMA	% of total project hrs	22.45
Failure QMA	% of total project hrs	19.85
Code Size	No. of Function Points	2191.83
Team Size	No. project personnel	11.19
Design Rework	% of total project hrs	0.44
Upfront Investment	% of total project hrs	13.64
Reuse	% of lines of code	5.26

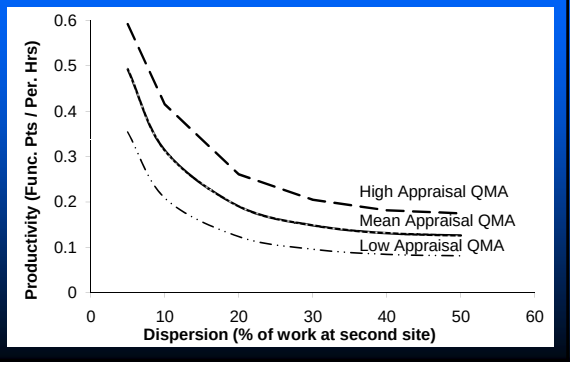
Hypothesis

1. *To what extent does "dispersion" in software tasks affect software productivity and quality?*
2. *To what extent can investments in structured software engineering processes mitigate the effect of dispersion?*
3. *What are the relative effects of individual quality management practices in improving distributed project performance?*

Dispersion & Project Performance



Dispersion & Project Performance



Hypothesis Revisited

1. *Does "dispersion" affect software productivity and quality?*
   - *Significant effect on productivity. Secondary effect on quality*
2. *Effect of structured software engineering processes on dispersion?*
   - *Quite a bit. These processes really do help*
3. *Relative effects of individual QMAs?*
   - *Productivity: Appraisal > Failure >>> Prevention*
   - *Quality: Failure > Prevention >>> Appraisal*

Limitations of Study

- *Only project-level aggregate data*
  - *No task-level analysis*
  - *Cultural and human factors not considered*
- *Unclear how generalizable the results are*
  - *Non CMM level 5 firms*
  - *Non custom business application development*

Conclusion

- Modeled distributed software development
- Investigated effect of dispersion on productivity and quality
  - Using data from a large software company
- Negative effects of dispersion can be mitigated
  - Using quality management approaches

Discussion

Dispersion & Project Performance

Hypothesis	Parameter	Development Productivity	Conformance Quality
1 A, B	Dispersion	-	-

- Interdependency (March and Simon 1958, Thomson 1967, Shea & Guzzo 1989)
- Trust Issues (Jarvenpaa & Leidner 1999, Sabherwal 1999)
- Coordination (Kraut et al 1990, Carmel 1999, Olson & Olson 2000)
- Mutual Knowledge (Cramton 2001)
- Software teams evidence (Carmel 1999, Mockus & Weiss 2001, Herbsleb & Mockus 2003)

Role of Quality Management

HYPOTHESIS	PRACTICE	EFFECT ON PRODUCTIVITY	EFFECT ON QUALITY
2 A,B	Prevention	+	+
3 A,B	Appraisal	+	+
4 A,B	Failure-based	-	+
5 A, B	Relative Returns	Appraisal > Failure	Failure > Appraisal

- Process research (Harter et al 2000, Smith et al. 2001, Zantek et al. 2002)
- Learning Theory (Fine 1986, Hatch & Mowery 1998, Pisano 1994)
- Cognitive load, complexity

Results

HYPOTHESIS	PARAMETER	EFFECT ON PRODUCTIVITY	EFFECT ON QUALITY
1 A, B	Dispersion	- (-)	- (-)
2 A,B	Prevention	+ (+)	NS (+)
3 A,B	Appraisal	+ (+)	NS (+)
4 A,B	Failure-based	NS (-)	+ (+)
5 A, B	Relative Returns	Appraisal > Failure	Failure > Appraisal

Key Results

- Dispersion negatively affects project performance even at high maturity levels
- Productivity – Quality tradeoffs present even at high maturity levels
- Returns from quality investments varied
  - Prevention & appraisal based quality process improve productivity
  - Failure based practices improve quality

Implications

- For Research
  - Project performance in high process maturity regimes
    - (CMM, Harter et al 2000, Krishnan et al 2000, Gopal et al 2002)
  - Cost of quality, Quality management
    - (Fine 1986, Nandakumar et al 1993, Slaughter 1998)
  - Organizing outsourced IT function
    - (Agarwal & Sambamurthy 2002, Sambamurthy & Zmud 2000)
- For Practitioners
  - Minimize cross site integration activities
  - Suitability of iterative development for dispersed tasks
  - Quality investments be guided by development context

Models→ Dependent Variable→	Parameter	(1) Development Productivity	(2) Conformance Quality	(3) Development Productivity	(4) Conformance Quality
Development Productivity	β_1	----	2.03*** (0.002)	----	2.02*** (0.002)
Conformance Quality	β_2	- 0.374*** (0.000)	----	- 0.382*** (0.000)	-----
Integration effort due to work dispersion	β_3	- 0.196*** (0.004)	- 0.404*** (0.013)	-0.152* (0.066)	-0.515** (0.018)
Aggregate Work Sharing (% onsite / total)	β_3	----	----	- 0.243 (0.332)	0.469 (0.449)
Defect Prevention	β_4	0.177* (0.075)	0.235 (0.259)	0.153 (0.134)	0.283 (0.183)
Task Appraisal	β5	0.404*** (0.006)	0.496 (0.147)	0.380** 0.011	0.522 (0.126)
Failure	β_6	0.2 (0.192)	0.746* (0.072)	0.256 (0.118)	0.744* (0.071)
Reuse	β_7	0.942*** (0.000)	--	0.942*** (0.000)	---
Team Size	β_8	- 0.443*** (0.004)	1.652** (0.022)	-0.429*** (0.005)	1.58** (0.025)
Project duration	β_9	- 0.344*** (0.002)	0.852** (0.031)	- 0.317*** (0.006)	0.824** (0.034)
Code Size	β_{10}	----	-2.36*** (0.000)	----	-2.36*** (0.00)
Code Coverage	β_{11}	----	- 0.463 (0.210)	----	-0.599 (0.142)
Constant	β_0	-3.962***	11.312** *	-3.43***	10.56***
Centered R-squared		0.663	0.564	0.66	0.57
F		11.23*** (0.00)	4.79*** (0.000)	9.71*** (0.000)	4.24*** (0.000)

Interview Transcript

- *Mutual Knowledge*

"…..I had worked on the customer's system from offshore for more than a year. But I never fully understand why my onsite coordinator initiated so many change requests for my work even after we had discussed its design before hand. Only when I visited onsite, I fully understood the production mechanism and end users' expectation. That's when I realized how different our views of the system where. I wish I can pass on this experience to my offshore colleagues; but it is not easy.…"

[Interview Transcript, Development Programmer, July 7, 2003]

Interview Transcript

- *Ambiguous Authority*

"……when I travel to my onsite and stay for few months it is not clear to me if my onsite manager passes on all information about my achievements to my offshore manager. Though my onsite manger monitors my task, it is my offshore manager who decides my annual bonus. Some times I feel I am at a disadvantage

Interview Transcript

- *Stress*

"…..my contract says my office time is flexible. Sometimes I spend all my time at office browsing the internet, chatting with friends and doing personal stuff because my colleagues at onsite have not responded. Other times I go home late continuously for a more than a week and I do not get time to spend with my family; it

Interview Transcript

- *Iterative development*

  "…..getting it right the first time with the aid of training and monitoring is no doubt cost effective and productive. But, when complexity exceeds certain limits and when our knowledge is uncertain it helps to go for quick builds, test and improve on subsequent builds. Building iteratively and repeated testing for conformance reduces uncertainty, gives immediate feedback and