Standardizing Product Development Processes

Sid Rupani, Presenter

LAI Web Knowledge Exchange Event

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We Share A Goal: Enterprise Excellence

AMCOM

Agenda

- Motivation and Overarching Question
- Map of Research Project
- Phase 1 – Immersion in Phenomenon - Case Studies
- Phase 2 – Detailed Project-Level Analysis
- Conclusions and Future Work

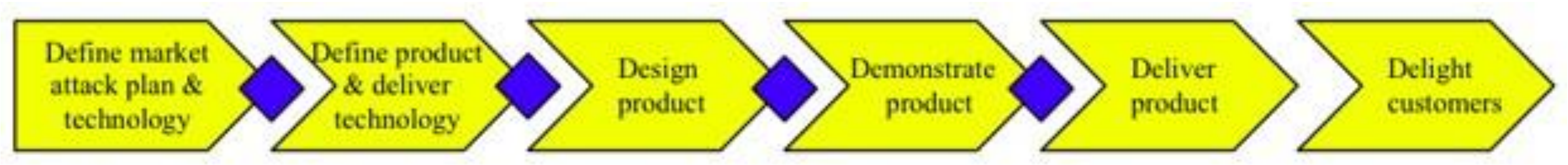
Product Development Process

- "A *product development process* is the sequence of steps or activities which an enterprise employs to conceive, design, and commercialize a product"

Ulrich and Eppinger 2000

- "Processes can be regarded and treated as systems that should be engineered purposefully and intelligently, facilitated by useful models."

Browning, Fricke, and Negele 2006



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The issue

"Companies made up of many different business units will face an important question as they make the shift to a process enterprise:

Should all units do things the same way, or should they be allowed to tailor the process to their own needs?

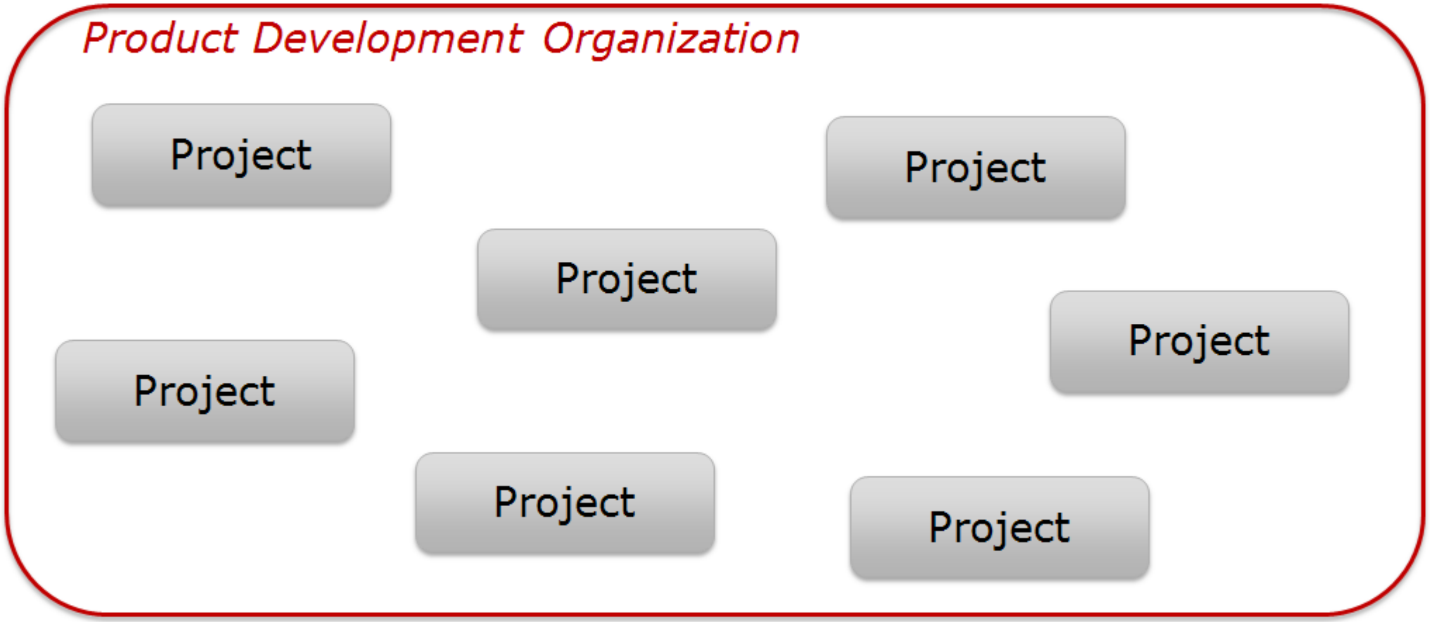
In a process enterprise the key structural issue is…process standardization versus process diversity.

There's no one right answer."

Hammer and Stanton

Harvard Business Review, 1999

Research Goal: To provide companies with guidance for effectively managing standardization and customization of their product development processes across multiple different projects



Overarching Question: What is the influence of process standardization on performance?

What is the influence of process standardization on performance?

Process Standardization

+

- Efficiency
- Knowledge Transfer
- Decision making / Resource Allocation

Adler et. al 1999; Morgan, Liker 2006

Argote 1999; Adler and Cole 1993

Hammer and Stanton 1999; Garvin 1998; Sobek, Liker, Ward 1998

-

- Project performance
- Innovation
- Creativity
- Adaptation/ Learning over time
- Employee Satisfaction

Krubasik 1988; Shenhar 2001

Benner & Tushman 2002

Tilcsik 2008; March 2007

March 1991; Levinthal and March 1993

Adler et al. 1999

"On both sides of the question, complex causal mechanisms play out in diverse ways in diverse situations. This might imply that we should not be aspiring to general conclusions with respect to the overall question, but rather seeking to sort out the mechanisms and the contingencies."

Sid Winter

in Adler et al. (2008)

Under what conditions and *how* does process standardization influence performance on project-level and organization-level outcomes?

Map of Research Project

Research Activity Undertaken

Phase I – Immersion in Phenomenon

3-month internship, Company Contacts, Secondary Sources

5 Company Case Studies
- Interviews
- Documents

Detailed Literature Study

Systematic study of 350+ papers from relevant areas

Phase II – In-depth study at one company

Collection and Analysis of detailed project, process, and project performance data

Lessons Learned

Phase I

Occurrence of process variation at different times, levels, sources

Importance of Individual Process Dimensions

Integrated framework and summary of current state of knowledge

Established, Contested, and Unexplored Links

Phase II

Links between project performance and variation from standard process at the studied company

Phase 1 – Immersion in Phenomenon: Case Studies

- Selected Cases (Theoretical Sample):
  - 5 large companies ($5B+ annual sales)
  - Develop electromechanical assembled products
  - Different industries (Computer Hardware, Aviation Electronics and Communication Equipment, Automobiles, Electronic Equipment)
  - Different approaches to process standardization

- Data Collection
  - Interviews (48 total) with various roles
  - Process documentation

Lessons from Case Studies: Individual Process Dimensions

"The biggest benefit is that because of the standard deliverables at the reviews, we all talk the same language and expect to see the same things in the same format. It's easy for the Senior Management Team to know when a red flag comes up or when a project is moving into exception."

Process Manager at Company E

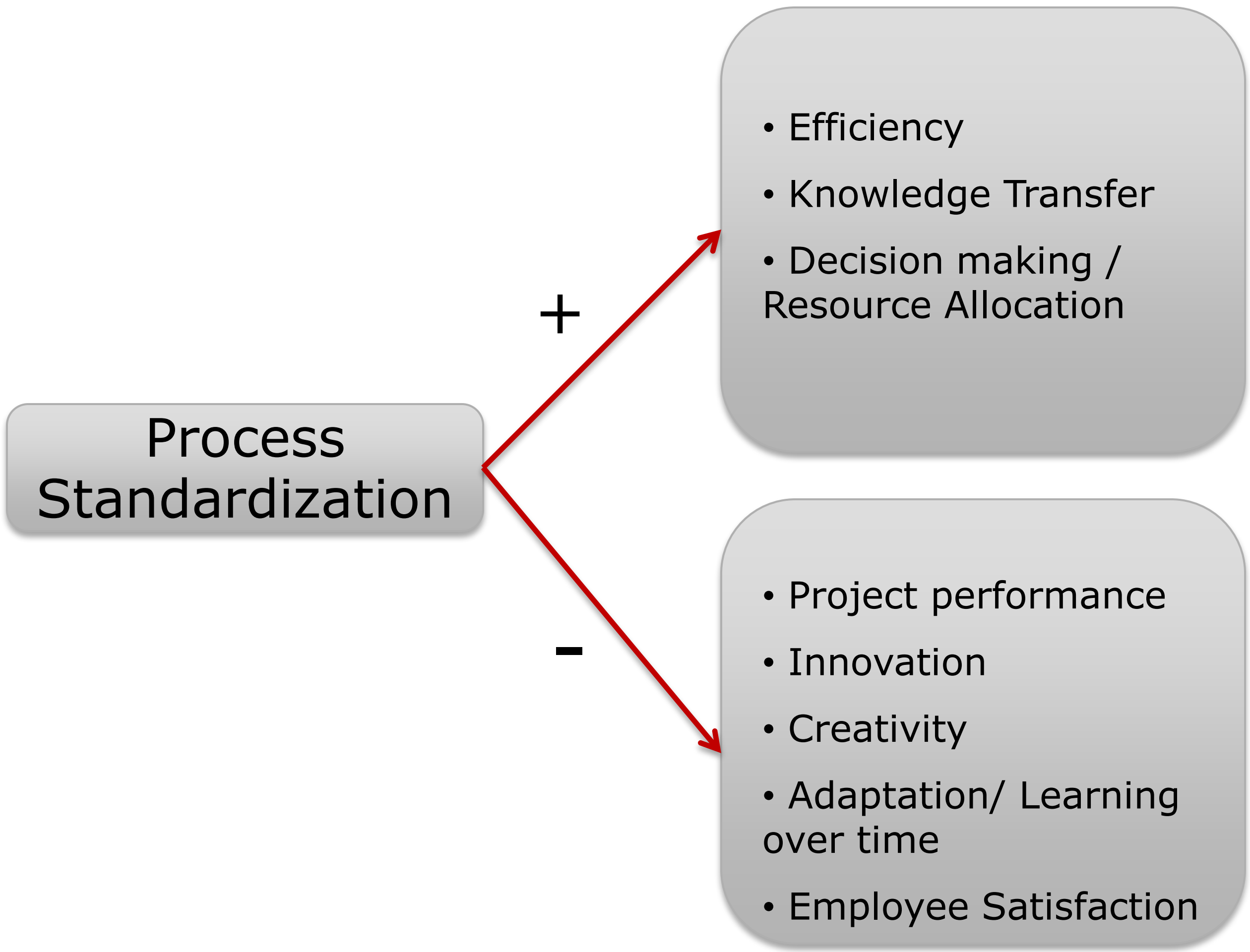
"One good thing was that since we started using the same tools, it allows us to easily move between projects. We didn't have to retrain every time we switched."

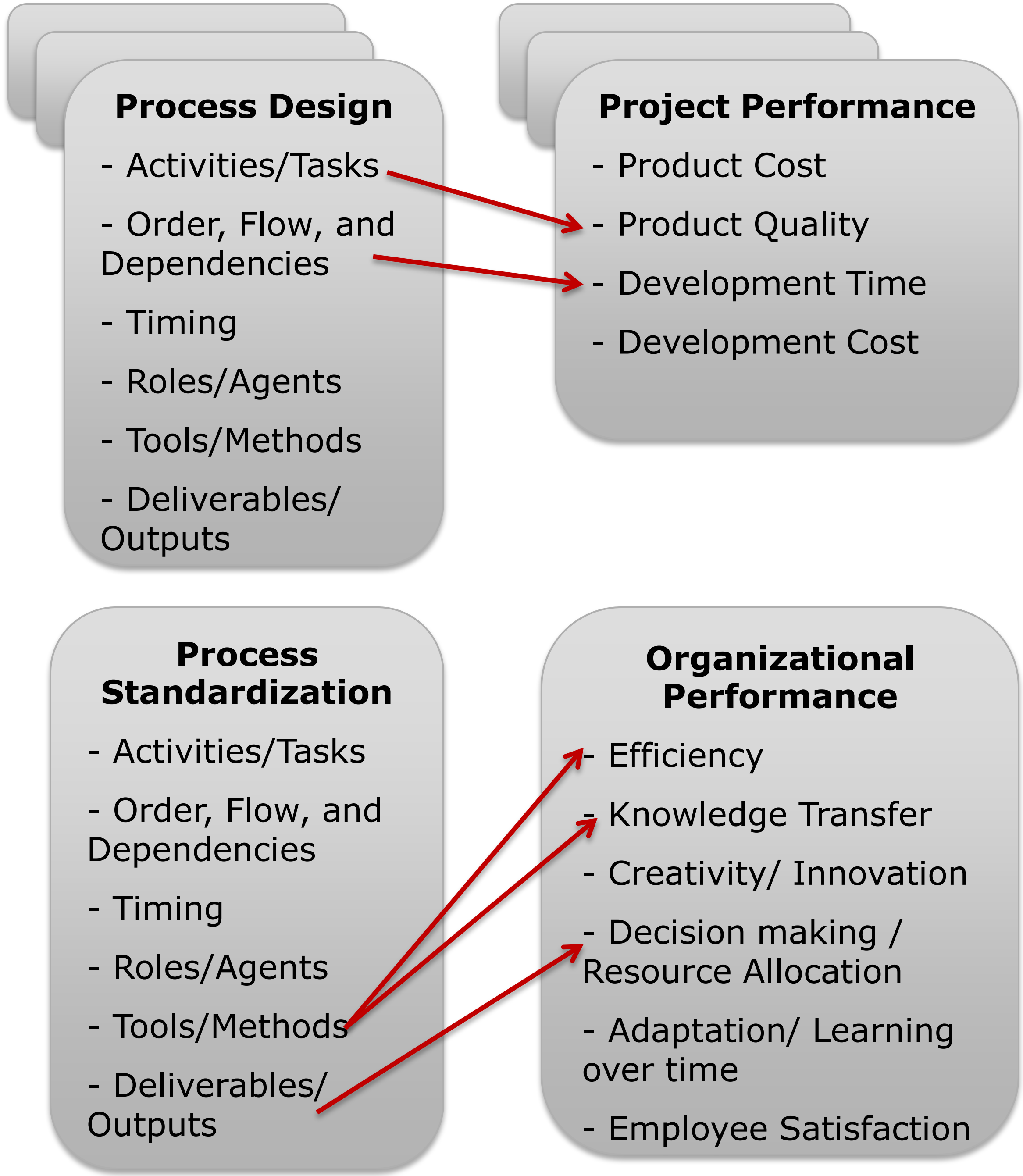
Engineer at Company E

"Because of the tools, we can get engineers from other projects in crunch time and they don't spend too much time ramping up. They can be integrated relatively seamlessly."

Project Manager at Company E

Lessons from Case Studies: Individual Process Dimensions




Process Design
- Activities/Tasks
- Order, Flow, and Dependencies
- Timing
- Roles/Agents
- Tools/Methods
- Deliverables/ Outputs
Project Performance
- Product Cost
- Product Quality
- Development Time
- Development Cost
Process Standardization
- Activities/Tasks
- Order, Flow, and Dependencies
- Timing
- Roles/Agents
- Tools/Methods
- Deliverables/ Outputs
Organizational Performance
- Efficiency
- Knowledge Transfer
- Creativity/ Innovation
- Decision making / Resource Allocation
- Adaptation/ Learning over time
- Employee Satisfaction

Lessons from Case Studies: Variation in Standardization Approach

- All companies
  - Acknowledged and controlled some amount of process variation, left some free to the discretion of project team

- Companies differed on:
  - What project characteristics they took into consideration to customize their process
  - Which process dimensions were centrally specified and which were left to project team's discretion

Company A

Computer Hardware

Inputs	Algorithm	Outputs
• Hardware/Software balance • Extent of In-House Development 8 Product 'Archetypes'	Table - each product archetype column, activities as rows. yes/no indicated.	• Activities

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Company A - Project Archetypes

	Product Type							
	Hardware	**Software (not MNL, not ABC)**	**Hardware & Software**	**Software OEM-in**	**Hardware OEM-in**	**Hardware Reseller**	**ABC Software**	**ABC XYZ Software**
Examples:	AB4000, AB5000, some Tape	none, except RST going to PQR	SVC		AB3000, Brokeman 20	Sysco PQR	Note: These are special in that are closely tied to system software of which ABC is a part	
Development								
Accessibility Checklist(s)							NA - handled by pDA	NA - done at major release. Not required for SPE maint
Anti-Smike - HW only		NA - not HW		NA - not HW			NA - not HW	NA - not HW
Cost of Originality (COO & VOO)						NA - not required for reseller	NA - handled by pDA	NA - done at release level
Chemical Emissions Data								
Finance								

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Company B

Avionics and Communication Equipment

Inputs	Algorithm	Outputs
• Complexity • Newness • Cost • Certifications • Technology Readiness • Business Unit • Testing Requirements • Support Requirements • Hardware/Software • Extent of Outsourcing • Supplier Quality • Production Needs 32 questions	Logic Table – each activity decision made by referring to answers for pertinent questions	• Activities (required and suggested) • *Deliverables* • *Templates* ~80 technical activities ~50 management activities

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Company B

A	B	C	D	E
	Q1		What is the projected cost of this project?	Select one.
☐	a		At or Above $ABC	
☒	b		Below $ABC	
	Q2		Please indicate maturity of technology on the project	Select one.
☐	a		Risky technology - unproven or limited application; emerging within market	
☒	b		Mature technology - proven and applied in similar applications; established within market	

A	B	C	D	E
"x"=YES	Req/ Audit	Cust Reqd	ACTIVITIES AND TASKS	DELIVERABLE
☒			**Capture Originating Requirements**	
☒		☐	1. Capture stakeholders needs	stakeholder needs
☒		☐	2. Capture source requirements.	source requirements
☒		☐	~~3. Capture architectural context.~~	~~architectural context(s)~~
☒		☐	4. Define most important	most important requirements
☒		☐	5. Define technical performance	technical performance measures (TPMs)
☐			**Define Concepts**	
☐		☐	~~1. Define concept.~~	~~concept~~
☐		☐	~~2. Perform conceptual analysis.~~	~~conceptual analysis document~~
☒	☑		**Define Requirements**	
☐		☐	1. Perform requirements trade	trade studies
☒	☑	☐	~~2. Define product requirements.~~	~~product requirements~~
☒	☑	☐	~~3. Conduct traceability analysis from~~	~~requirements trace/ analysis~~
☒		☐	4. Perform functional hazard	functional hazard assessment

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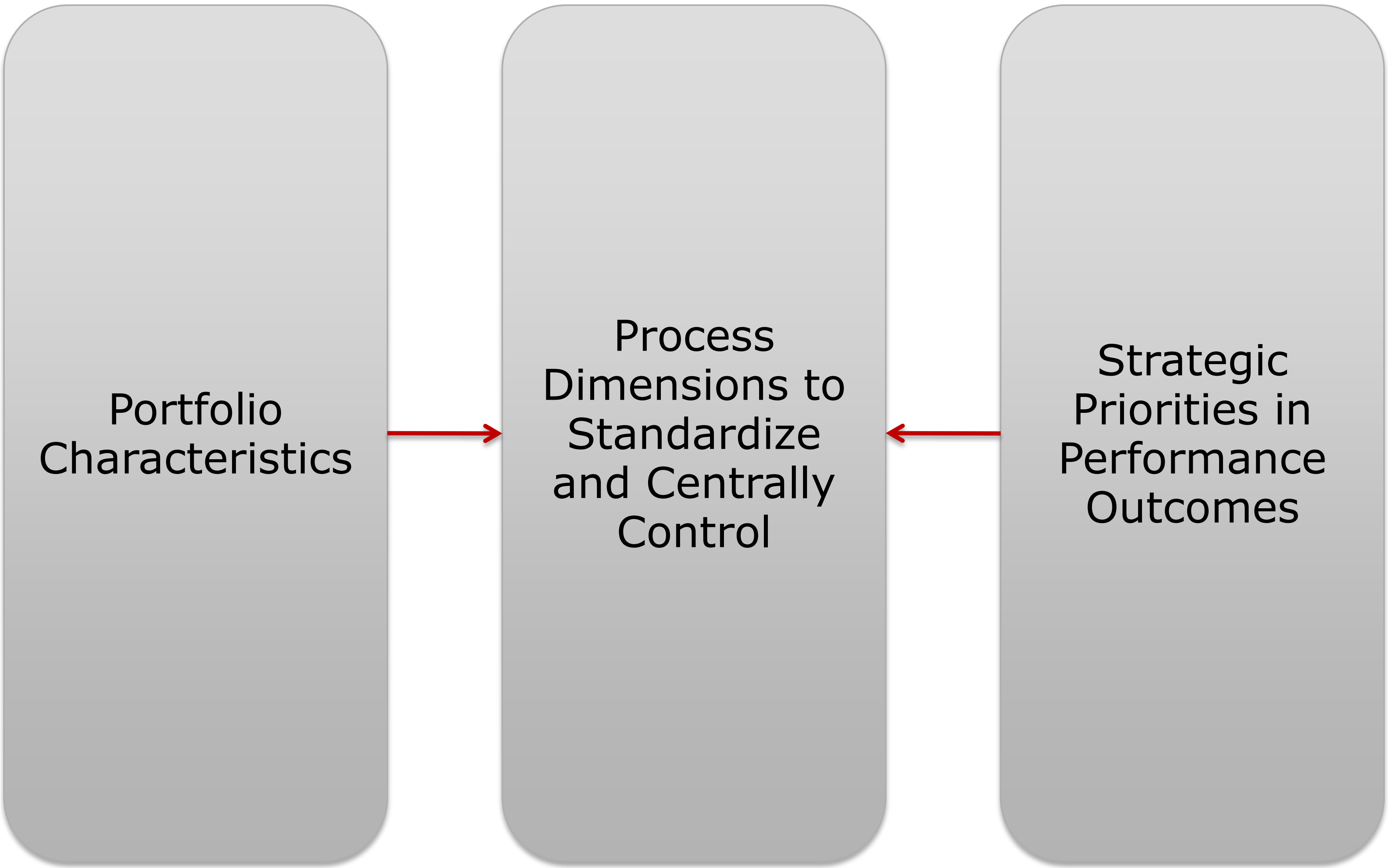
Company C

Automotive

Inputs	Algorithm	Outputs
"Degree of Product Change" in three key subsystems Rated from 1-6	Three digit code maps to a "timing template"	• Activities • Sequence • Timing • (Reviews) • Deliverables • Templates • Roles

Why do companies differ in process standardization approach?

- Because they differ on:
  - Variation in project characteristics across portfolio
  - Strategic priorities across performance outcomes


Portfolio Characteristics
Process Dimensions to Standardize and Centrally Control
Strategic Priorities in Performance Outcomes

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Link to Phase II

Process Standardization's impact on Project Performance

- Why Project Performance?
  - *Contested*: Oft-cited negative performance effect of process standardization, in literature and practice. Prior literature inconclusive – studied process standardization at high level
  - *Salient*: Project performance outcomes are directly relevant and very familiar to managers.
  - *Important*: Other outcomes translate into improvement on project performance and organizations actively manage project performance.
  - *Data Available*: Data on organizational performance outcomes unavailable or subjective. Objective data on project performance available.

Phase 2 Electronic Equipment Co.

Detailed examination of project level process data within one company

- Detailed data on 15 projects (18 products)

	Project Characteristics	Process Design	Project Performance
Variables	- Complexity - Newness - Extent supplier development - Resources - Agents (PM)	- Reviews/Gates - Deliverables - Activities - Time spent	- Quality (Reliability) - Development Cost - Schedule - Unit Product Cost
Primary Data Sources	*Product Data Sheet* *Product Requirements Document*	*Review Presentations* *Meeting Minutes*	*Customer Satisfaction and Reliability Reviews (12 out of 15)* *Project Schedules*

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Analysis Strategy

Control Variables	*Independent Variables of interest*	*Dependent Variables*
Project Characteristics	**Process Design**	**Project Performance**
- Complexity	- Reviews/Gates	Quality (Service Cost Overrun)
- Newness	- Deliverable Waivers	Development Cost (and overrun)
- Extent of supplier development	- Activities (Testing)	Schedule (and overrun)
- Resources	- Time spent in Phases	Unit Manufacturing Cost Overrun
- Project Manager		

Explaining Development Time

Results of Regression Analysis for Development Time in Weeks

Variable	Model 1	Model 2	Model 3	Model 4	Model 5
Newness Low Dummy	-20.72***	-17.48**	-20.18***	-13.51	-16.30*
Newness High Dummy	-7.08	-7.91	-6.49	-5.67	-5.72
Complexity Low Dummy	-2.75	-2.01	-3.93	-4.60	-0.75
Complexity High Dummy	8.88	15.07*	16.71**	17.65*	16.47*
Ext. of dev. done by supplier Low Dummy		-6.43			
Ext. of dev. done by supplier High Dummy		3.48			
Resources (FTEs)			-0.15	-0.20	-0.15
Project Manager 1 Dummy				-9.29	-4.65
Project Manager 2 Dummy				-9.82	-3.41
Project Manager 3 Dummy				-8.25	-4.23
Combined Gates Dummy					-7.32
Intercept	51.91***	49.36***	57.77***	62.69***	62.58***
Adjusted R^2	0.723	0.712	0.749	0.763	0.778

* p < .10 ; ** p < .05; *** p < .01

Explaining Development Cost

Results of Regression Analysis for Engineering Spend in $m

Variable	Model 1	Model 2	Model 3	Model 4	Model 5
Newness Low Dummy	-1.59	1.38	0.86	2.52	0.84
Newness High Dummy	-0.64	-1.66	-1.61	-1.34	-1.18
Complexity Low Dummy	-1.10	-1.19	-0.96	-1.54	-0.29
Complexity High Dummy	8.89***	11.22***	9.55***	10.22**	9.46***
Ext. of dev. done by supplier Low Dummy		3.63***	2.92*	3.18	4.98***
Ext. of dev. done by supplier High Dummy		5.76***	4.88**	4.60	4.34***
Resources (FTEs)			.027		
Project Manager 1 Dummy				-1.08	
Project Manager 2 Dummy				-2.76	
Project Manager 3 Dummy				-0.76	
Combined Gates Dummy					-2.60**
Intercept	5.97***	2.35**	1.85	3.60	4.50***
Adjusted R^2	0.714	0.940	0.937	0.930	0.967

* p < .10 ; ** p < .05; *** p < .01

Explaining Service Cost Overrun - $

Results of Regression Analysis for Service Cost Overrun in $ (per machine per year)

Variable	Model 1	Model 2	Model 3	Model 4	Model 5
Newness Low Dummy	-41.9	-178.3	-28.8	-86.9	-122.6
Newness High Dummy	-142.0	-137.9	-139.1	-145.3	-168.9*
Complexity Low Dummy	53.6	39.1	65.5	77.1	-54.02
Complexity High Dummy	172.8	101.5	111.3	188.4	125.7
Ext. of dev. done by supplier Low Dummy		93.4			
Ext. of dev. done by supplier High Dummy		-117.8			
Resources (FTEs)			1.44		
Project Manager 1 Dummy				9.84	
Project Manager 2 Dummy				77.9	
Project Manager 3 Dummy				-12.2	
Combined Gates Dummy					201.7**
Testing (Prototypes and Software Builds)					
Intercept	2.97	127.0	-70.8	-7.98	-37.4
Adjusted R^2	0.076	0.065	-0.007	-0.516	0.601

* $p < .10$; ** $p < .05$; *** $p < .01$

For service cost overrun, n= 12

Consequences of Process Customization: Gate Combination

- Gate combination associated with:
  - reduced development time by 10.5 weeks
  - reduced development cost by $2.6m
- Gate combination associated with reduced testing
  - When gates are combined projects do 3.66 less tests
- Testing is strongly negatively related to service cost overrun
  - Each unit of testing associated with reduction in service cost overrun of $33.91 (no other significant predictors of service cost overrun)
  - Each unit of testing reduces total service cost overrun/year (each product overrun multiplied by 80% of intended sales for that product) by $0.77m
  - Gate combination is associated with an increased service cost overrun of $2.81m/year (0.77m x 3.66). This is a conservative estimate. Direct regression shows increase of $4.34m/year.
- Products are serviced for at least two, often three, years.
- The negative spillover effects of gate combination in terms of increased service cost easily outweigh the benefits.

Conclusions from Phase 2

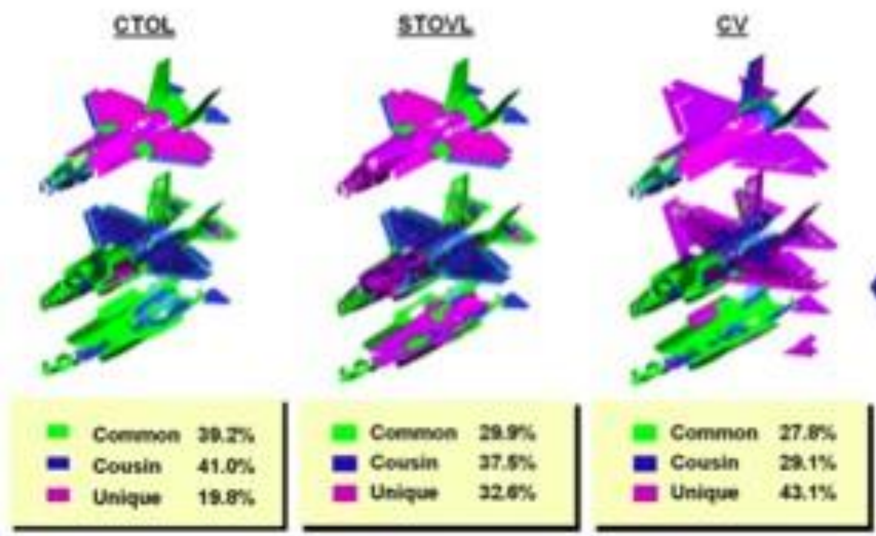
- Variation on different process dimensions associated with different performance effects
- Results indicate that variations from the process standard (specific variations, not all) are associated with net negative project performance outcomes.
- Results support that process standardization can be beneficial for project performance even across varied projects

Contributions and Future Work

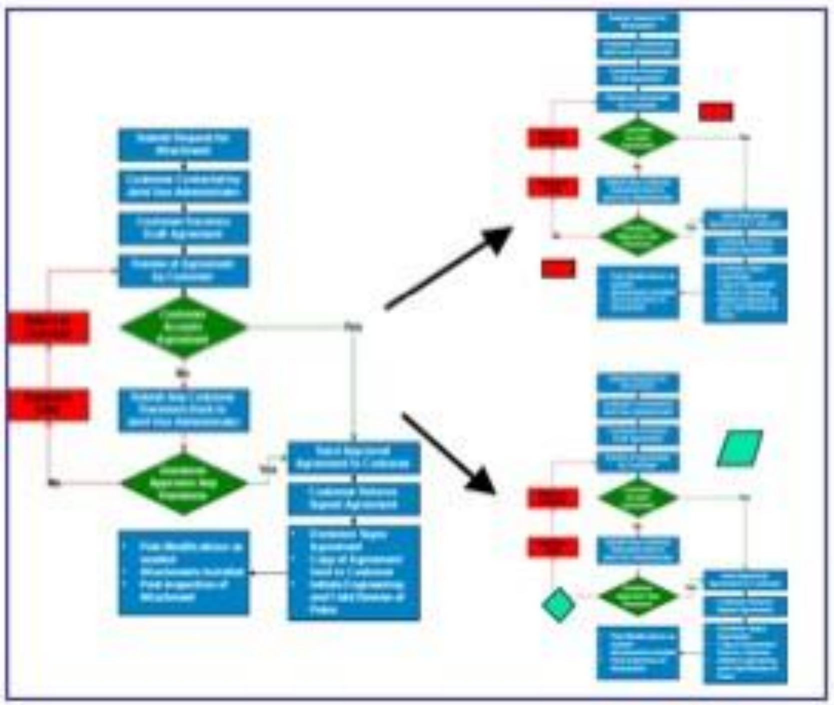
- Importance of individual process dimensions
- Framework to aid organizations in decision making about process standardization
- Evidence from one company that standard process can be associated with better performance across varied projects

- Need to extend work to other companies
  - Seeking generalizability
  - Seeking understanding of company contingencies

Thank You!



Source: http://www.jsf.mil/, accessed July 6, 2006



Questions? Comments?