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Evolution of a Bluetooth Test Application Product Line: A Case Study

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Structure of Presentation

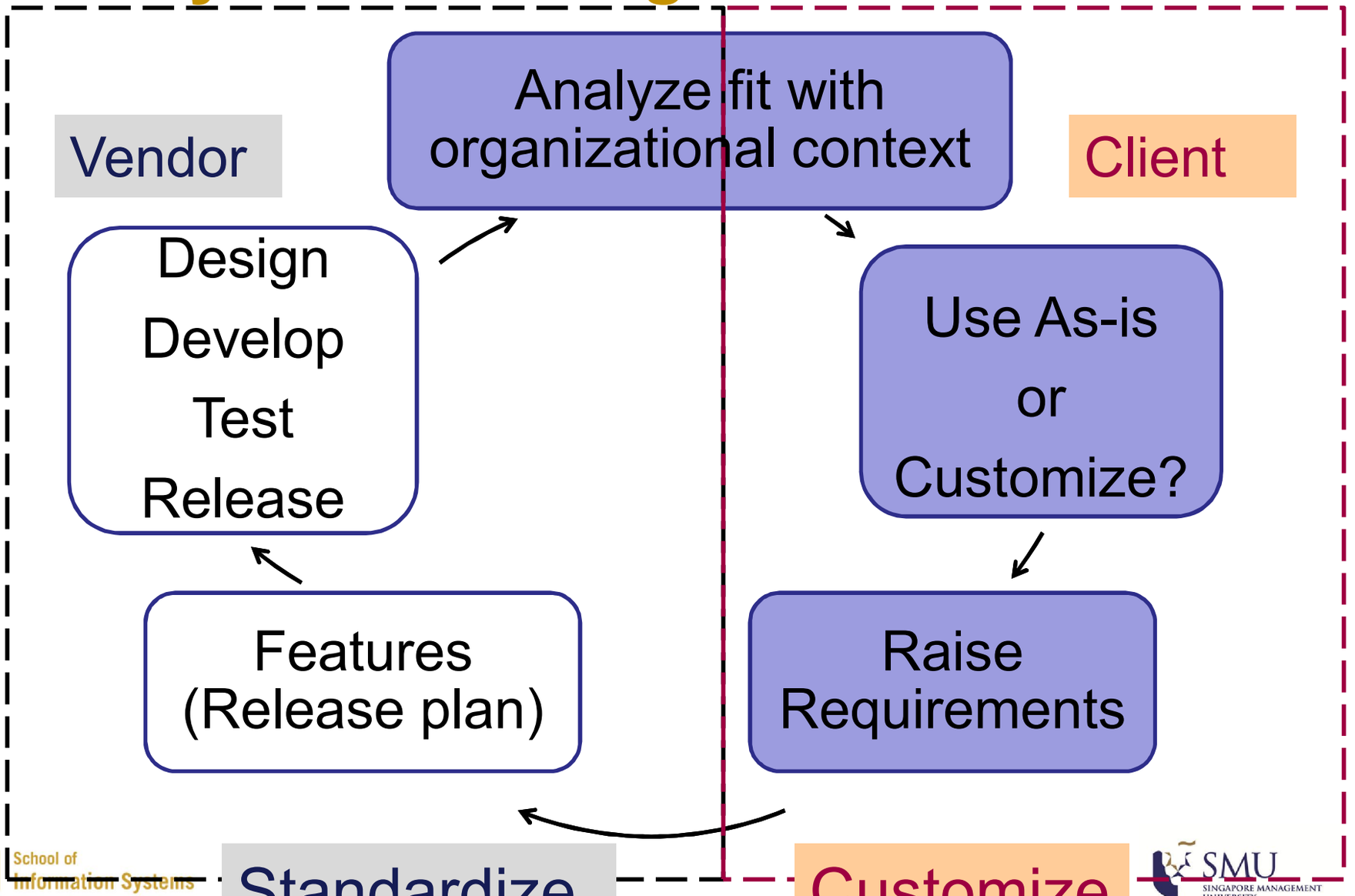
- Research problem overview
- Empirical Context
- Standardization-Customization (S-C) decision model
- Product Variability cost model
- Discussion / broader takeaways

Packaged software business

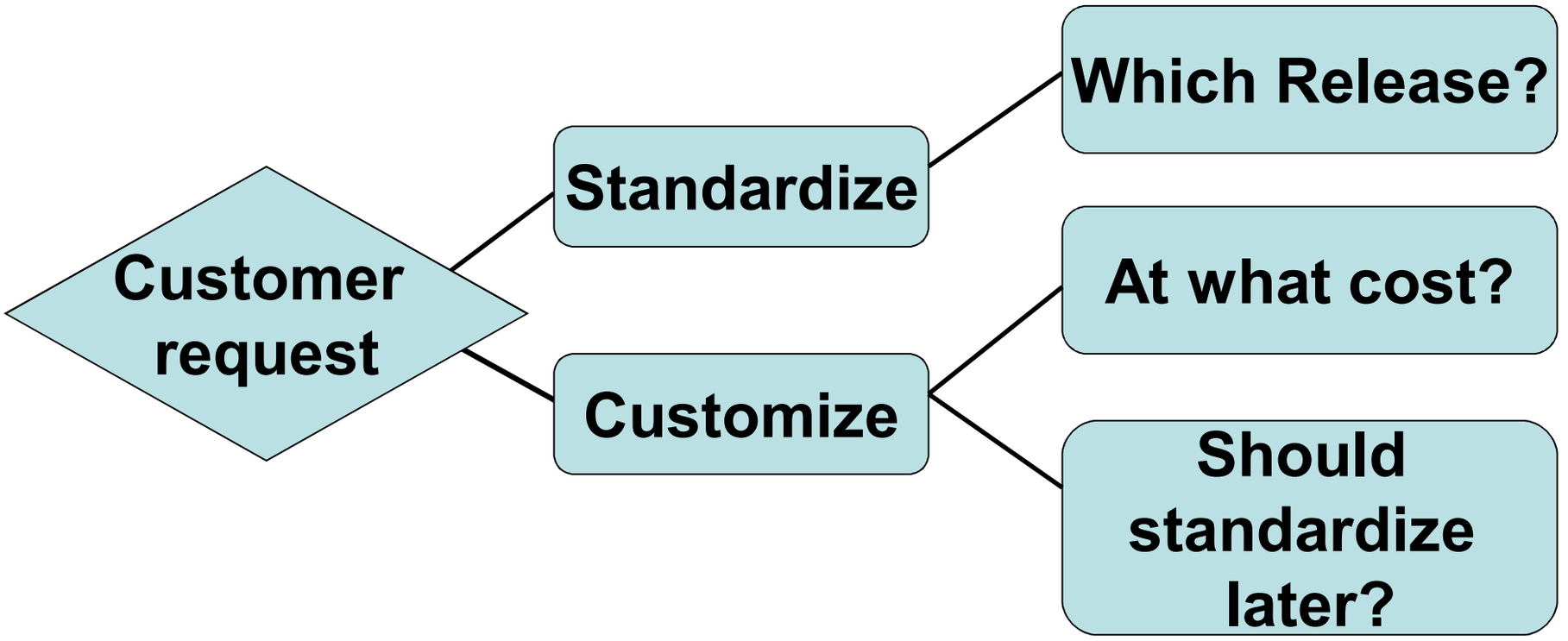
- Packaged software is big business
  - $10 billion (IDC 2009-10 forecast)
  - ERP, CRM, supply chain systems, office productivity

- a.k.a. “Off the shelf”, “COTS”

Lifecycle of Packaged Software



Vendor's Dilemma / Decision



Research Questions

- What factors affect the standardization-customization decision?
  - An important step towards a generalizable theory of product line evolution

- How do you estimate customization costs (i.e., product variability costs)?

Empirical Context – the research site

- Measuretronics (not real name)
  - Wireless test and measurement product firm
  - Over $1.5 billion in product sales
  - Over 700 active technology patents
  - About 400 customers (firms) worldwide

Empirical Context – the product line

- Bluetooth Protocol Analyzer
  - test and measurement instrument used in the production of Bluetooth consumer products
- Hardware component
- Software component
  - Firmware (Operating system)
    - Capture test and measurement data
  - Client software
    - Analyze test and measurement data

Data Collection

- Participatory action research
  - Researchers co-investigate with or involve the communities whose practices they study
  - three-member core team
    - One of the authors
    - One program manager (who was a marketing specialist)
    - One engineering manager
- All product decisions between 1999-2003

Data Collection (Continued)

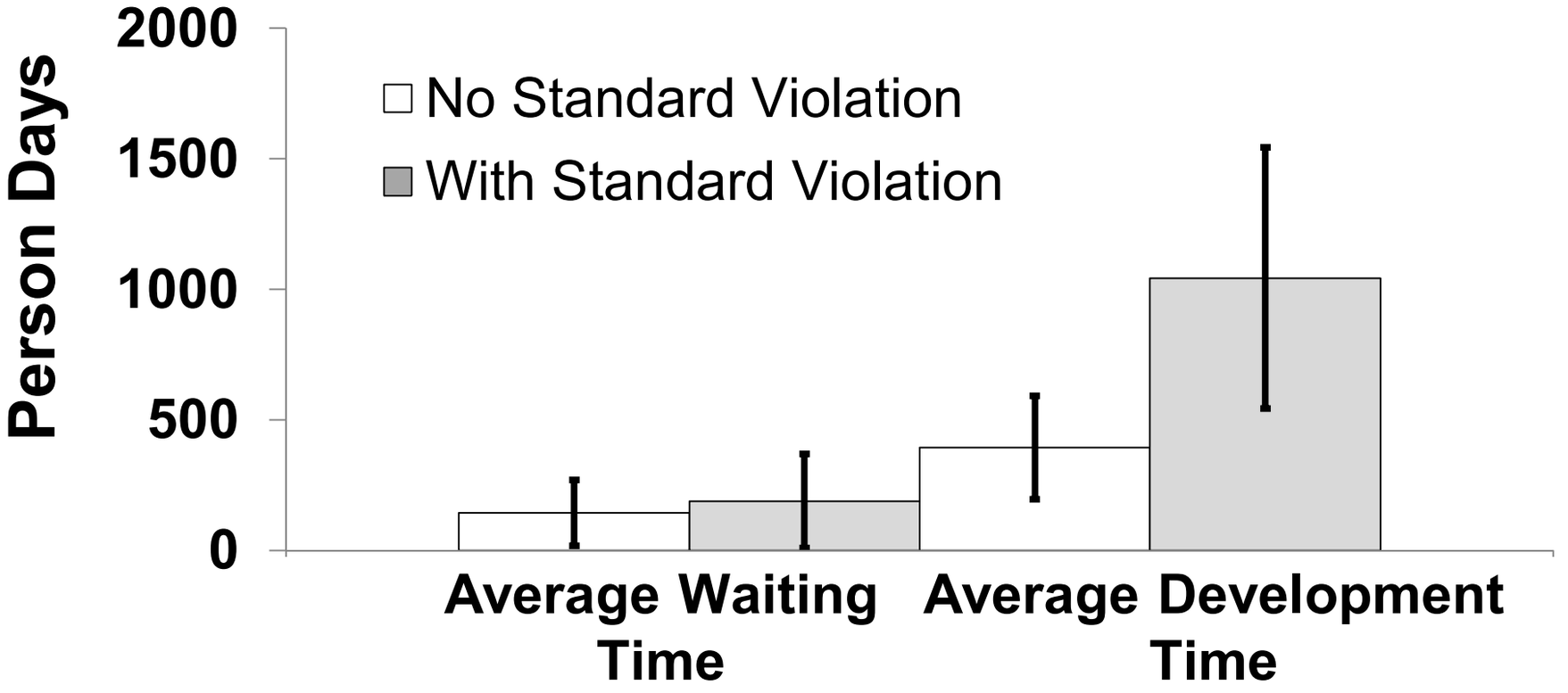
- Collected Data
  - In-depth records of product functional features and specification changes
  - In-depth process records detailing the product development processes and choices made
  - Structured interviews and group discussions
  - 154 customer requests. 2 to 1 S-C ratio

Standardization-Customization (S-C)?

- Major influential factors (from empirical data)
  - Evolving Standards
  - Competition
  - Compatibility
  - Nature of Change
  - Complexity

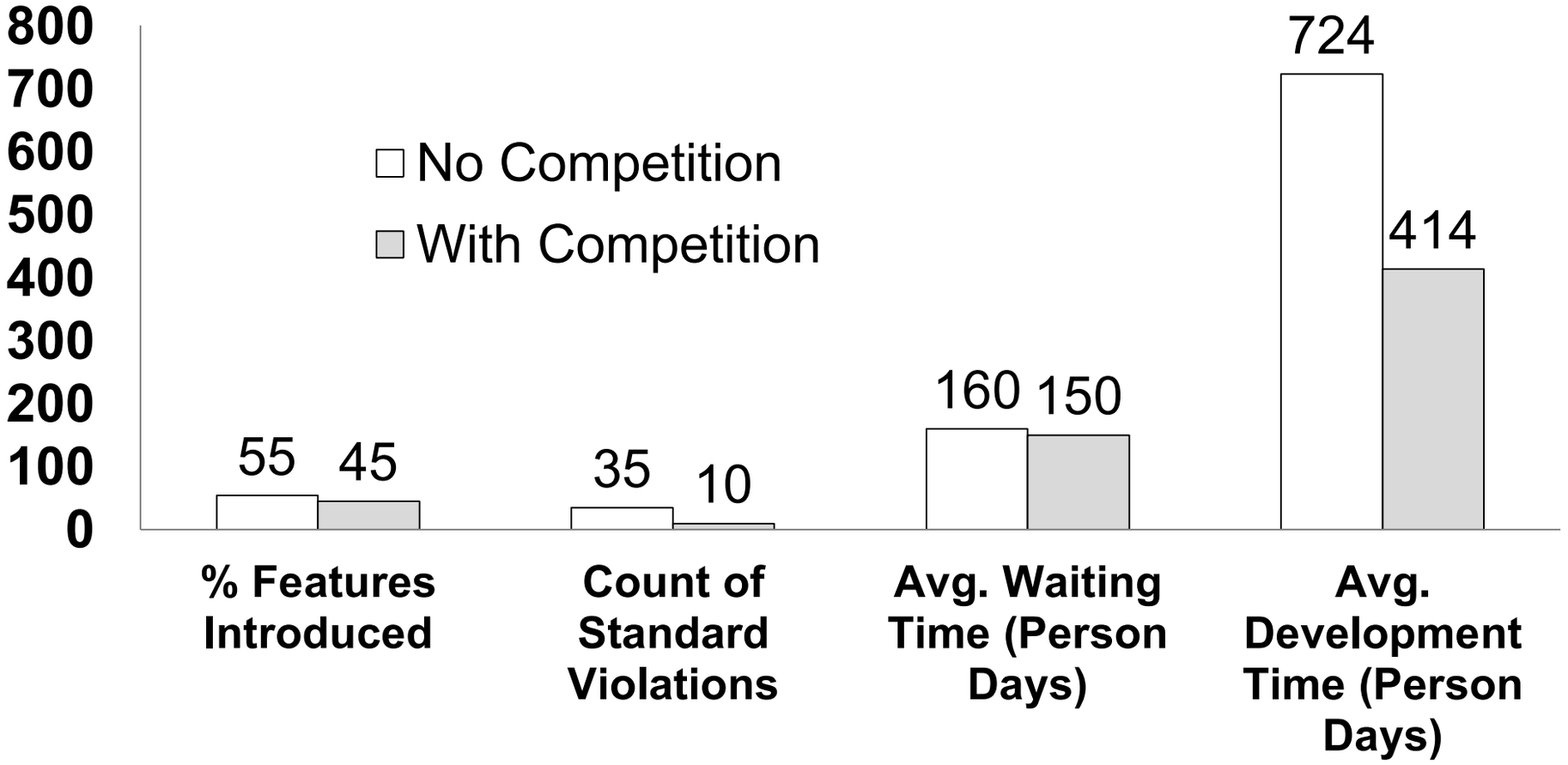
Evolving Standards

- Uncertainty over Bluetooth standards
  - Need to be one step ahead of consumer product firms (Microsoft, Sony, Nokia, Motorola, etc)



Competition

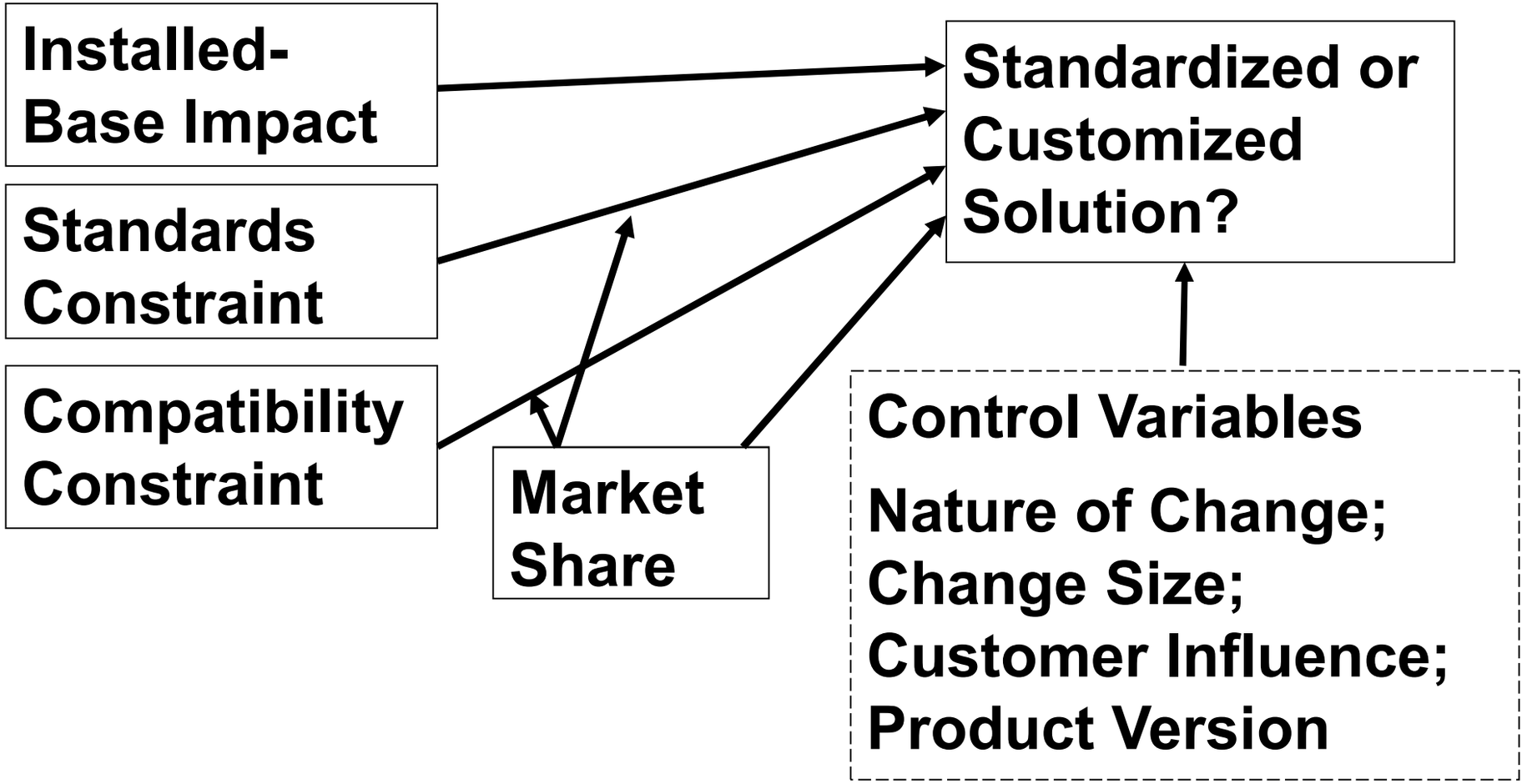
- > ½ of product features - no direct competition
- Sensitive to being “ahead of competitors”



Modeling S-C Decisions

- Collective influence of variables need to be examined
  - Interaction effects
- Generalizable software product line evolution theory

Empirical Model



Modeling S-C Results Summary

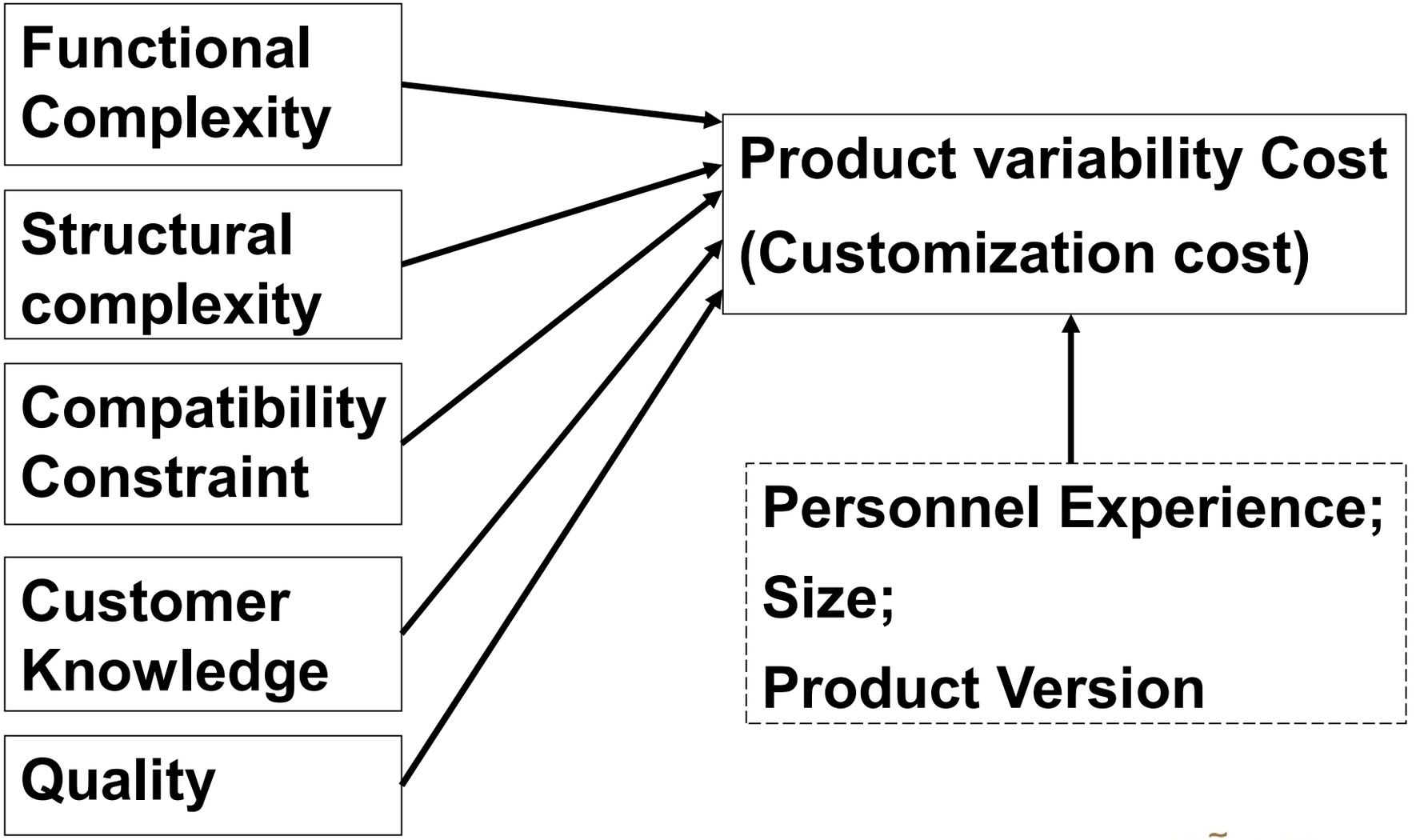
- Pro-customization factors
  - Increased Market Share
  - Standards Violation
  - Needed by customer
  - Incompatible with previous versions

- Pro-standardization factors
  - Incompatibility when you have market share
  - Impact on product obsolescence strategies

Customization Costs

- Estimating costs for product line variations
- An important variant of software cost estimation problem
- Needs to accommodate factors from the standardization-customization decision model

Empirical Model



S-C Costs Results Summary

- Increases Costs
  - Functional complexity
  - Structural complexity
  - Incompatible requests
  - Error-prone components

- Decreases Costs
  - Customer specific knowledge
  - Experienced personnel

Most Important Takeaways

1. Predictive model for S-C decisions
   - towards a generalizable product line evolution theory
2. A cost estimation model for S-C decisions
   - Models variability in product line evolution
3. Timing product feature obsolescence
   - Universal policies on compatibility not optimal
4. Economic incentives for reducing complexity
   - Reducing structural complexity of products has downstream benefits
5. Invest in organizational memory
   - Knowledge transfer between development, marketing, and implementation teams

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Thank You

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Most Important Takeaway

6. Rejections are just another opportunity
   - This paper for example
   - Use the feedback to improve the paper
     - No such thing as a “perfect” paper!
   - Keep persevering and good things will happen!

Most Important Takeaways

1. Product line governance
   - Align the incentives for solving engineering problems and meeting market opportunities
2. Timing product feature obsolescence
   - Universal policies on compatibility not optimal
3. Economic incentives for reducing complexity
   - Reducing structural complexity of products has downstream benefits
4. Invest in Organizational memory
   - Knowledge transfer between development, marketing, and implementation teams

Major Contributions

1. Examined the S-C dilemma
   – constantly changing specifications originating from standards evolution and diverse customer requirements

2. Predictive model for S-C decisions
   – a step towards a generalizable theory of software product line evolution

3. A cost estimation model for S-C decisions
   – Models economic aspects of variability in product line evolution

Modeling S-C Empirical Model Specification

- Probability (Standardized or Customized Solution?) =

$$\Phi [\alpha_0 + \alpha_1 * \text{Installed-base impact} + \alpha_2 * \text{Compatibility constraint} + \alpha_3 * \text{Standards constraint} + \alpha_4 * \text{Market share} + \alpha_5 * \text{Customer influence} + \alpha_6 * \text{Market share} * \text{Compatibility constraint} + \alpha_7 * \text{Market share} * \text{Standards constraint} + \alpha_8 * \text{Change size} + \alpha_9 * \text{Version} + \alpha_{10} * \text{Nature of change} + \delta]$$

Modeling S-C Results

Variable		Effect of one unit change on the probability to standardize a customer request
Installed-Base Impact	α_1	**-0.007****
Compatibility Constraint	α_2	**-0.52****
Standards Constraint	α_3	**-0.61****
Market Share	α_4	**-0.02****
Customer Influence	α_5	**0.27****
Interaction effect: Market Share X Compatibility Constraint	α_6	**0.25***
Interaction effect: Market Share X Standards Constraint	α_7	-0.02
Change Size	α_8	**-0.003****
Version	α_9	0.007
Nature of Change	α_{10}	**-0.3***

S-C Cost Empirical Specification

- Customization Cost =

$\beta_0 + \beta_1$*Functional Complexity + β_2*Structural Complexity + β_{3*} Compatibility Constraint + β_4* Customer Knowledge + β_5* Quality + β_6* Personnel Experience + β_7* Size + β_8* Version + ε

Customization Cost Results

Variable		Coefficient.	P-value
Functional Complexity	β_1	0.25**	0.035
Structural Complexity	β_2	3.57**	0.017
Compatibility Constraint	β_3	175.59***	0.004
Customer Knowledge	β_4	-0.53**	0.036
Quality	β_5	10.88**	0.024
Personnel Experience	β_6	-28.08*	0.073
Size	β_7	0.022	0.123
Version	β_8	-1.97	0.302
constant	β_0	247.95**	0.024
Number of Observations = 51 Model Significance test F-stat (8, 42) = 9.28***, P-value = 0.000 Adj.R-Squared = 56.99%; Mean MRE = 19%			