COLLEGE of BUSINESS
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

Information System Flexibility and the Cost Efficiency of Business Processes*

Judith Gebauer

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* with Franz Schober;
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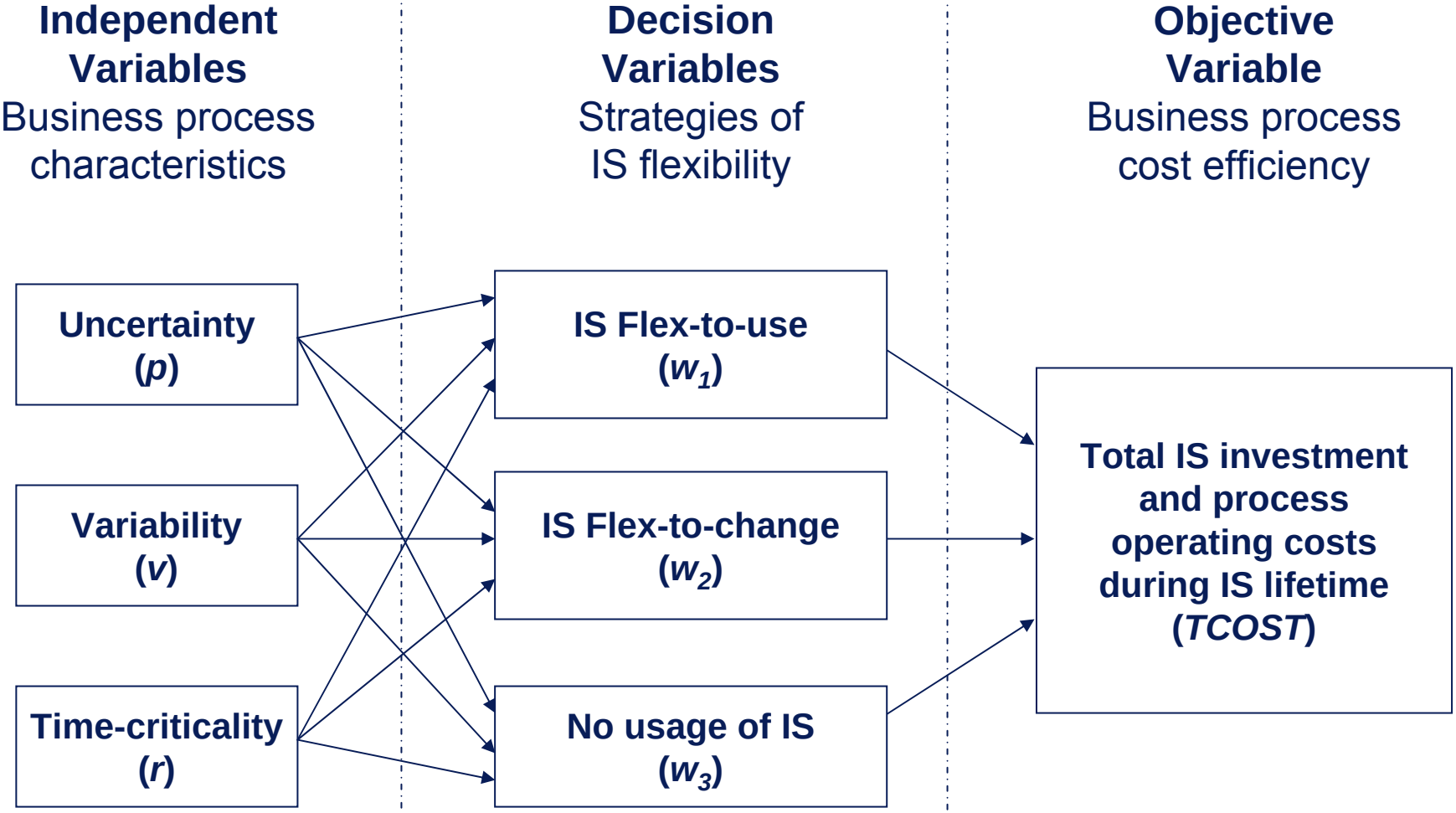
Research Objective

Based on the **assumptions**, that

- Too little flexibility as well as too much flexibility can limit the effectiveness of an information system (IS), and that
- IS flexibility causes cost,

We focus on the economics of IS flexibility, seeking to determine **the optimal level and type of IS flexibility for the cost-efficient support of a given business process.**

Model Structure



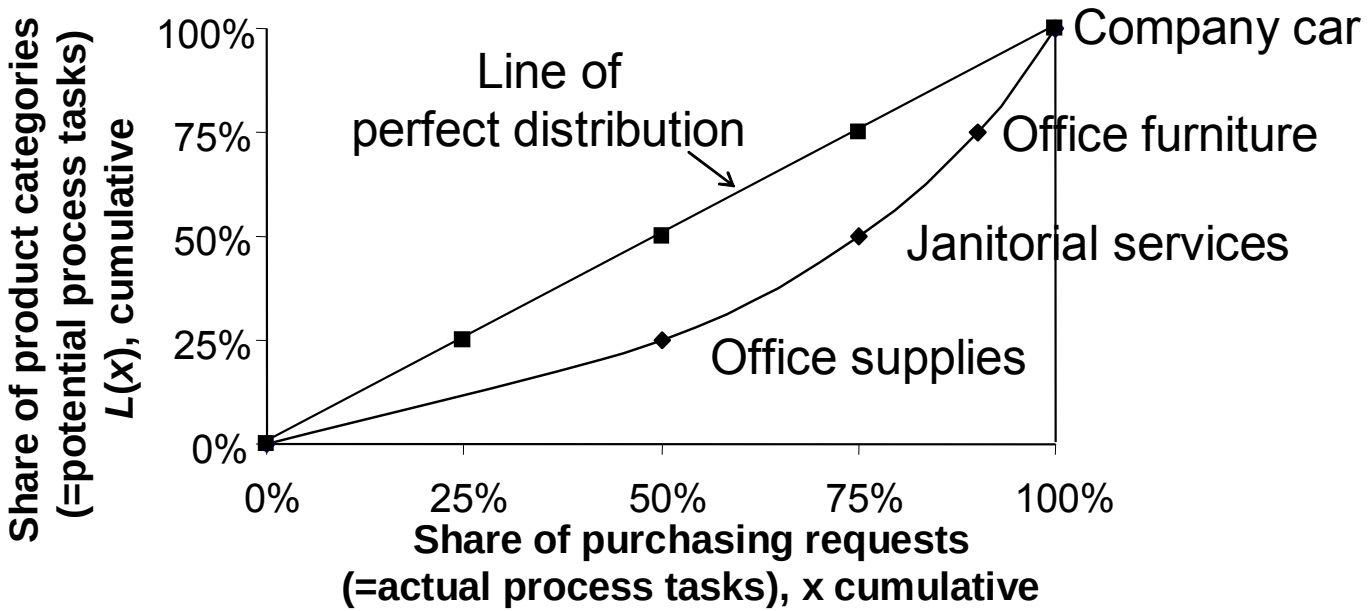
Decision Variables: Strategies of IS- Flexibility

- **IS-flexibility-to-use** (scope of application) (w_1)
  - System functionality
  - Scope of database
  - User interface
  - Processing capacity
- **IS-flexibility-to-change** (upgradability; conceptually similar IS infrastructure and real options) (w_2)
  - Personnel
  - Integration of data and functionality
  - Modularity of system components
- **No usage of IS** (manual operations, outsourcing etc.) (w_3)

Independent Variables: Business Process Characteristics

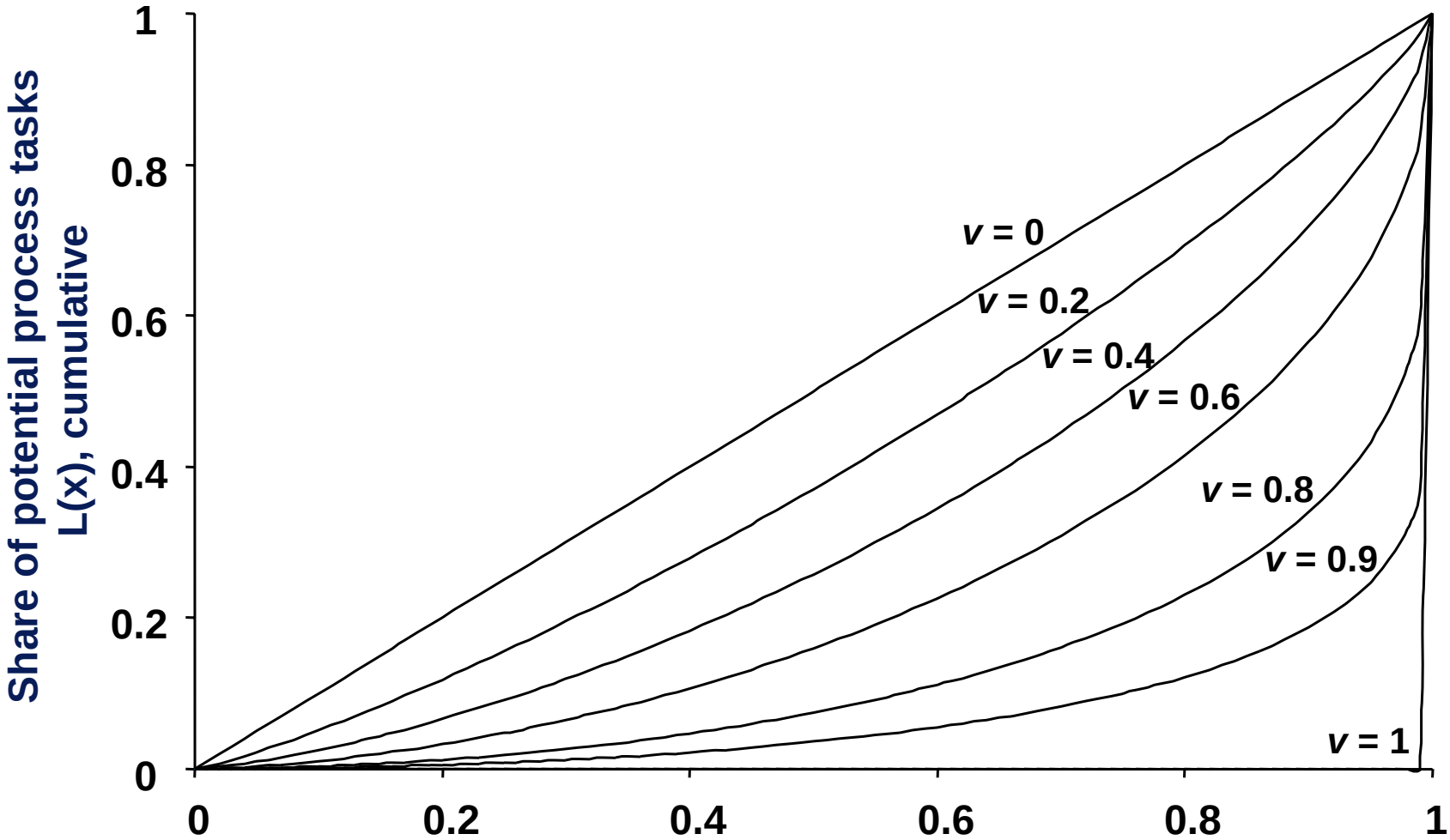
- **Uncertainty (*p*)**
  - Environmental uncertainty of exogenous Variables
  - Structural uncertainty (*non-routineness*)
  - Determines the predictability of process requirements
- **Variability (*v*)**
  - Distribution of different process requirements during the IS-lifetime (Lorenz-curve for graphical representation)
- **Time-Criticality (*r*)**
  - Extent to which the performance of a business process is time-critical

Lorenz Curve as a Measure of Process Variability

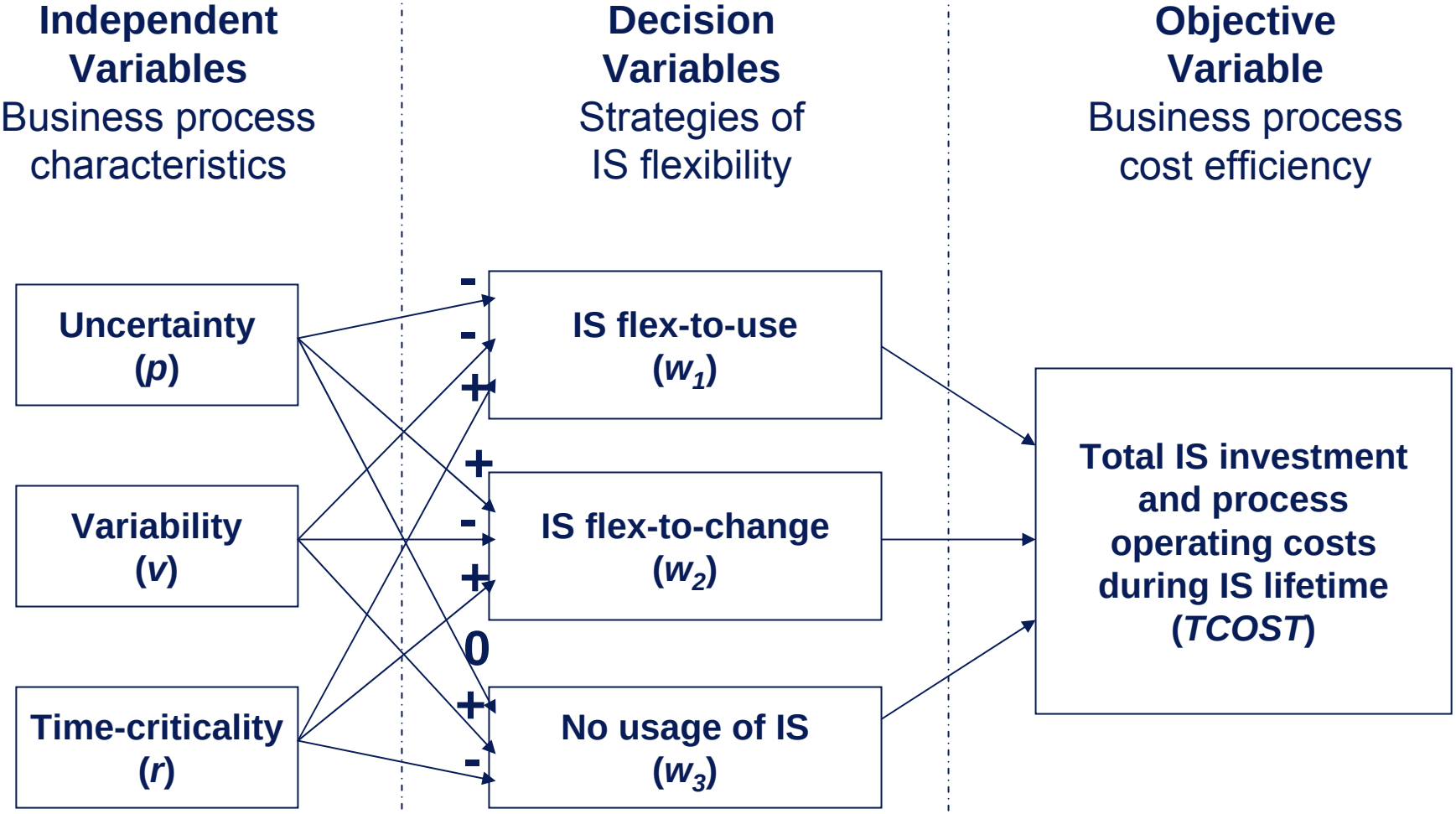


	Share of product categories (=potential process tasks) L(x), cumulative	Share of purchasing requests (=actual process tasks), x cumulative
Office supplies	25%	50%
Janitorial services	50%	75%
Office furniture	75 %	90%
Company car	100%	100%

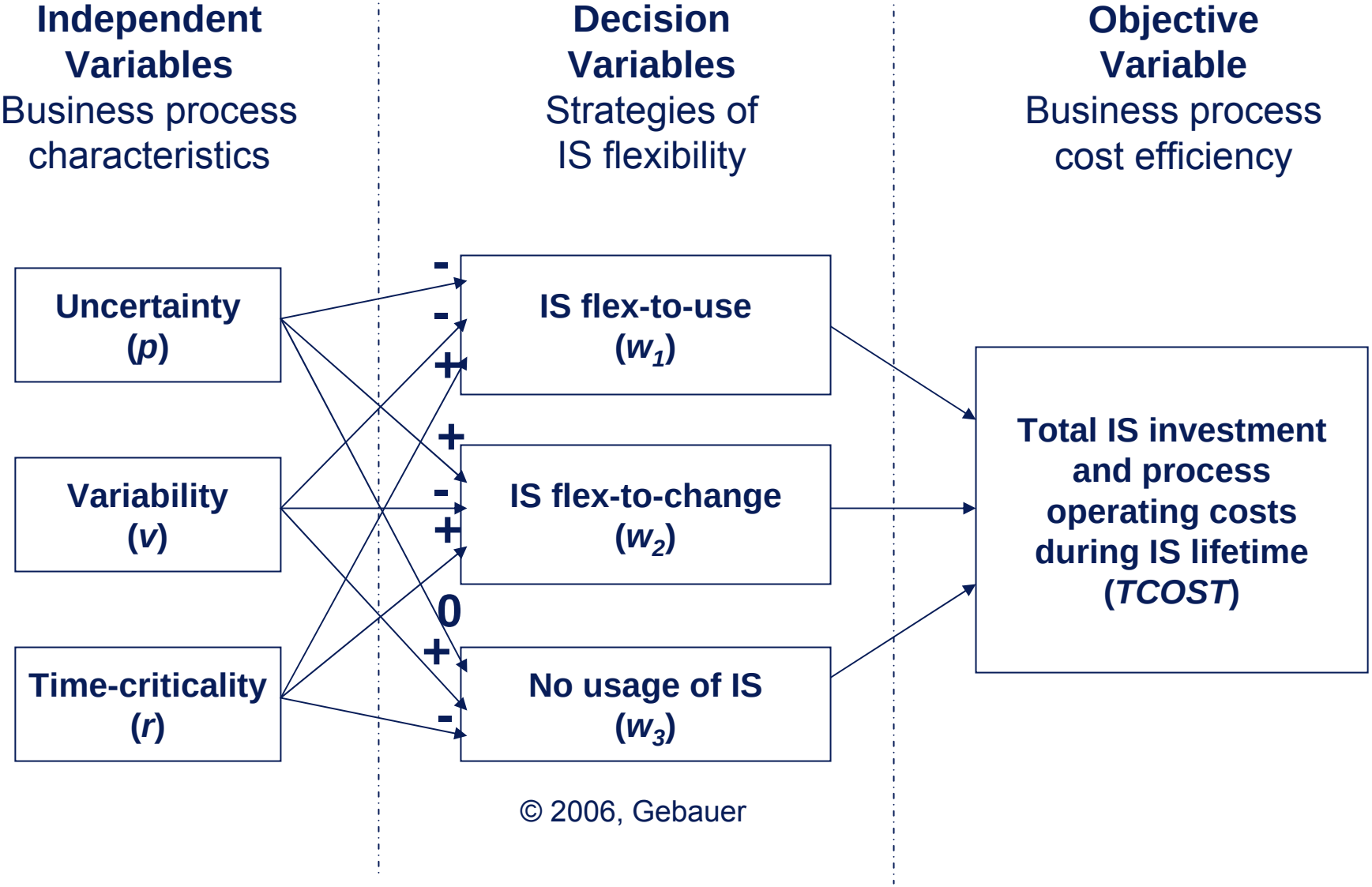
Lorenz Curves for Different Levels of Variability *v* (Ortega et al. 1991)



Optimization Model – Preliminary Propositions



Optimization Model – Preliminary Propositions



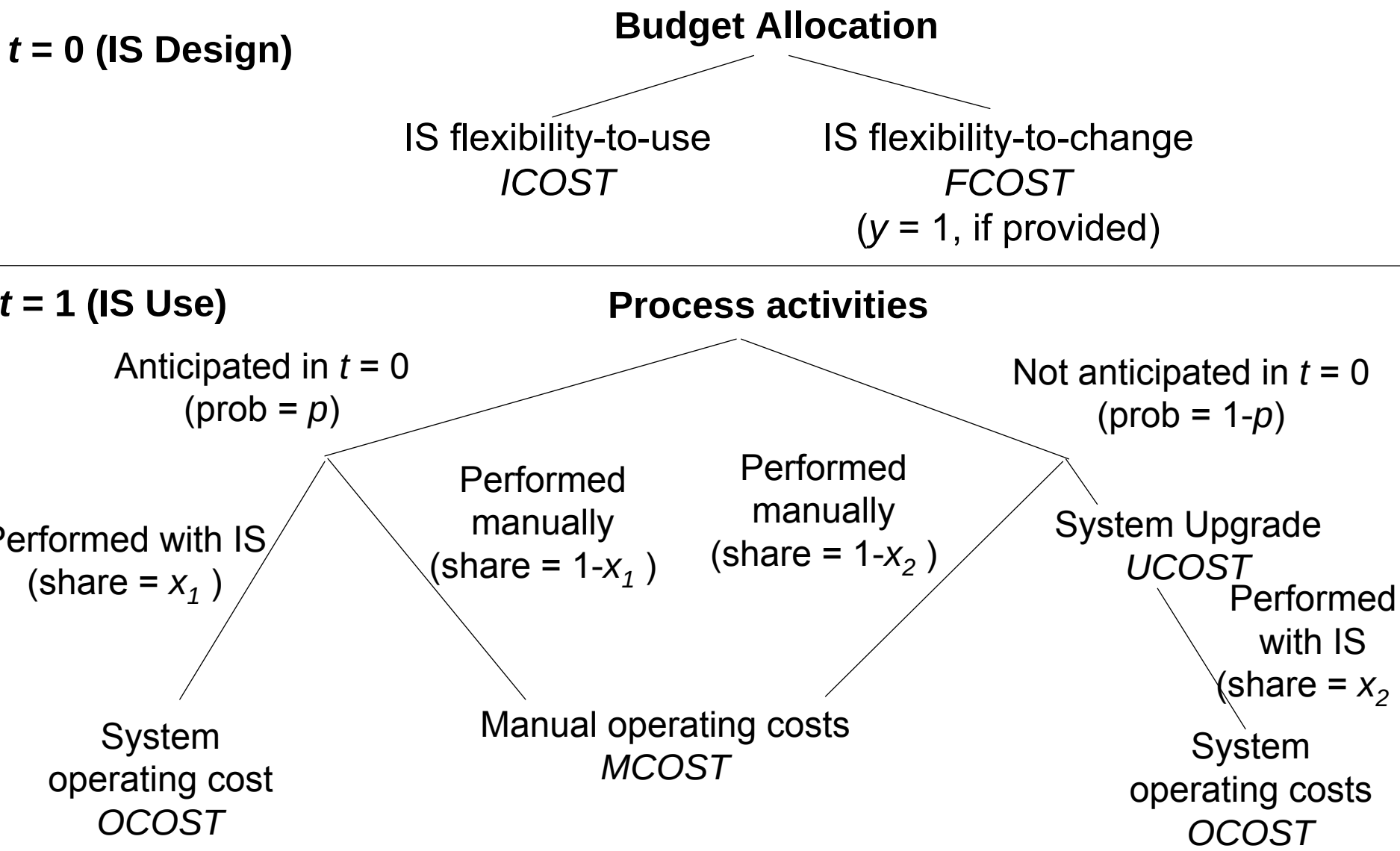
Preliminary Propositions (1)

- **Proposition A (Uncertainty effect, *p*)**
  A business process characterized by **low uncertainty** (high value of *p*) can be supported cost efficiently based on IS flexibility-to-use.
  ... by **high uncertainty** ... based on flexibility-to-change.
- **Proposition B (Variability effect, *v*)**
  ... by **low variability** can generally be supported cost efficiently with an IS.
- ... by **high variability** may not warrant the inclusion of all different process tasks into the IS, making it efficient to perform some process tasks outside of the system.

Preliminary Propositions (2)

- **Proposition C (Time-criticality effect, *r*)**
  A business process characterized by **high time-criticality** can be performed cost efficiently with an IS,
  ... by **low time-criticality**, the IS investment may not outweigh the cost premium to be paid for tasks that are performed outside of the system.

Two-Step Decision Process



Decision Variabiles

- x_1: Share of process tasks anticipated in $t = 0$ and using flexibility-to-use in $t = 1$
- x_2: Share of process tasks not anticipated in $t = 0$ and using flexibility-to-change in $t = 1$

Strategy-mix determined by uncertainty factor p:

- $w_1 = px_1$
- $w_2 = (1\text{-}p)\, x_2$
- $w_3 = p\,(1\text{-}x_1) + (1\text{-}p)\,(1\text{-}x_2) = 1 - w_1 - w_2$

Cost Factors (1)

- **Investment in IS flexibility-to-use (*t* = 0)**

  $ICOST = a + b\ L(x_1)$

- **Investment in IS flexibility-to-change (*t* = 0)**

  $FCOST = c*y$

- **System operating costs (*t* = 1)**

  $OCOST = d\ [w_1 + w_2]$

- **System upgrade costs (*t* = 1)**

  $UCOST = e\ L(x_2)$

- **Manual processing costs (*t* = 1)**

  $MCOST = f\ (1 + r\ g)\ w_3$

Cost Factors (2)

- **Lorenz curve to measure process variability**

  $L(x) = x^v [1 - (1 - x)^{1-v}]$

- **Total costs, to be minimized**

  $TCOST = ICOST + FCOST + OCOST + UCOST + MCOST$

  with $0 \leq x_1, x_2 \leq 1$ and $y \in \{0,1\}$

Model Analysis (1): Low Uncertainty, Variable Variability, No Time-Criticality

Costs: a = 100, b = 300, c = 50, d = 800, e = 300, f = 1,500, g = 0.7				
Low uncertainty (p = 0.8), no time-criticality (r = 0)				
Variability (v)	IS flexibility-to-use (w_1)	IS flexibility-to-change (w_2)	No use of IS (w_3)	Total cost ($TCOST$)
0 = high	0.80	0.00	0.20	1,340
0.2	0.78	0.00	0.22	1,337
0.4	0.73	0.00	0.27	1,311
0.6	0.72	0.00	0.28	1,266
0.8	0.74	0.13	0.13	1,195
0.9	0.76	0.16	0.08	1,116
1 = low	0.80	0.20	0.00	950

Model analysis (2): Medium Uncertainty, Variable Variability, No Time-Criticality

Costs: a = 100, b = 300, c = 50, d = 800, e = 300, f = 1,500, g = 0.7				
Medium uncertainty (p = 0.5), no time-criticality (r = 0)				
Variability (v)	IS flexibility-to-use (w_1)	IS flexibility-to-change (w_2)	No use of IS (w_3)	Total cost ($TCOST$)
0 = high	0.50	0 (0.50)	0.50 (0)	1,550 (1,550)
0.2	0.37	0.37	0.26	1,505
0.4	0.37	0.37	0.26	1,427
0.6	0.39	0.39	0.22	1,339
0.8	0.43	0.43	0.14	1,221
0.9	0.46	0.46	0.08	1,130
1 = low	0.50	0.50	0.00	950

Model Analysis (3): High Uncertainty Variable Variability, No Time-Criticality

Cost: a = 100, b = 300, c = 50, d = 800, e = 300, f = 1,500, g = 0.7				
High uncertainty (p = 0.2), no time-criticality (r = 0)				
Variability (v)	IS flexibility-to-use (w_1)	IS flexibility-to-change (w_2)	No use of IS (w_3)	Total costs ($TCOST$)
0 = high	0	0.80	0.20	1,390
0.2	0.01	0.78	0.21	1,386
0.4	0.04	0.73	0.23	1,353
0.6	0.08	0.72	0.20	1,291
0.8	0.13	0.74	0.13	1,195
0.9	0.16	0.77	0.07	1,116
1 = low	0.20	0.80	0.00	950

Propositions (1)

- **Proposition 1a:** A business process characterized by **low uncertainty** and **high variability** can be supported cost efficiently with an IS that is based predominantly on flexibility-to-use and that is complemented by manual operations.
- **Proposition 1b:** A business process characterized by **low uncertainty** and **low variability** can be supported cost efficiently with an IS that is based predominantly on flexibility-to-use and that is complemented by IS flexibility-to-change.

Propositions (2)

- **Proposition 2a:** A business process characterized by **medium uncertainty** and **high variability** can be supported cost efficiently with an IS that is based equally on flexibility-to-use and on flexibility-to-change and that is complemented by manual operations.
- **Proposition 2b:** A business process characterized by **medium uncertainty** and **low variability** can be supported cost efficiently with an IS that is based equally on flexibility-to-use and on flexibility-to-change strategies with a negligible share of manual operations.

Propositions (3)

- **Proposition 3a:** A business process characterized by **high uncertainty** and **high variability** can be supported cost efficiently with an IS that is based predominantly on flexibility-to-change and that is complemented by manual operations.
- **Proposition 3b:** A business process characterized by **high uncertainty** and **low variability** can be supported cost efficiently with an IS that is based predominantly on flexibility-to-change and that is complemented by flexibility-to-use.

Model Analysis (4): Low Uncertainty, Variable Variability, High Time-Criticality

Costs: a = 100, b = 300, c = 50, d = 800, e = 300, f = 1,500, g = 0.7				
Low uncertainty (p = 0.8), high time-criticality (r = 0.5)				
Variability (v)	IS flexibility-to-use (w_1)	IS flexibility-to-change (w_2)	No use of IS (w_3)	Total costs ($TCOST$)
0 = high	0.80	0	0.20	1,445
0.2	0.80	0	0.20	1,445
0.4	0.78	0	0.22	1,434
0.6	0.77	0.13	0.10	1,366
0.8	0.77	0.16	0.07	1,245
0.9	0.78	0.18	0.04	1,145
1 = low	0.80	0.20	0.00	950

Model analysis (5): Medium Uncertainty, Variable Variability, High Time-Criticality

Costs: a = 100, b = 300, c = 50, d = 800, e = 300, f = 1,500, g = 0.7				
Medium uncertainty (p = 0.5), high time-criticality (r = 0.5)				
Variability (v)	IS flexibility-to-use (w_1)	IS flexibility-to-change (w_2)	No use of IS (w_3)	Total costs ($TCOST$)
0 = high	0.50	0.50 (0)	0 (0.50)	1,550 (1,813)
0.2	0.49	0.49	0.02	1,546
0.4	0.47	0.47	0.06	1,500
0.6	0.46	0.46	0.08	1,411
0.8	0.47	0.47	0.06	1,269
0.9	0.48	0.48	0.04	1,158
1 = low	0.50	0.50	0.00	950

Model analysis (6): High Uncertainty, Variable Variability, High Time-Criticality

Costs: a = 100, b = 300, c = 50, d = 800, e = 300, f = 1,500, g = 0.7				
High uncertainty (p = 0.2), high time-criticality (r = 0.5)				
Variability (v)	IS flexibility-to-use (w_1)	IS flexibility-to-change (w_2)	No use of IS (w_3)	Total costs ($TCOST$)
0 = high	0.00	0.80	0.20	1,495
0.2	0.06	0.80	0.14	1,480
0.4	0.10	0.78	0.11	1,439
0.6	0.13	0.77	0.10	1,366
0.8	0.16	0.77	0.07	1,245
0.9	0.18	0.78	0.04	1,145
1 = low	0.20	0.80	0.00	950

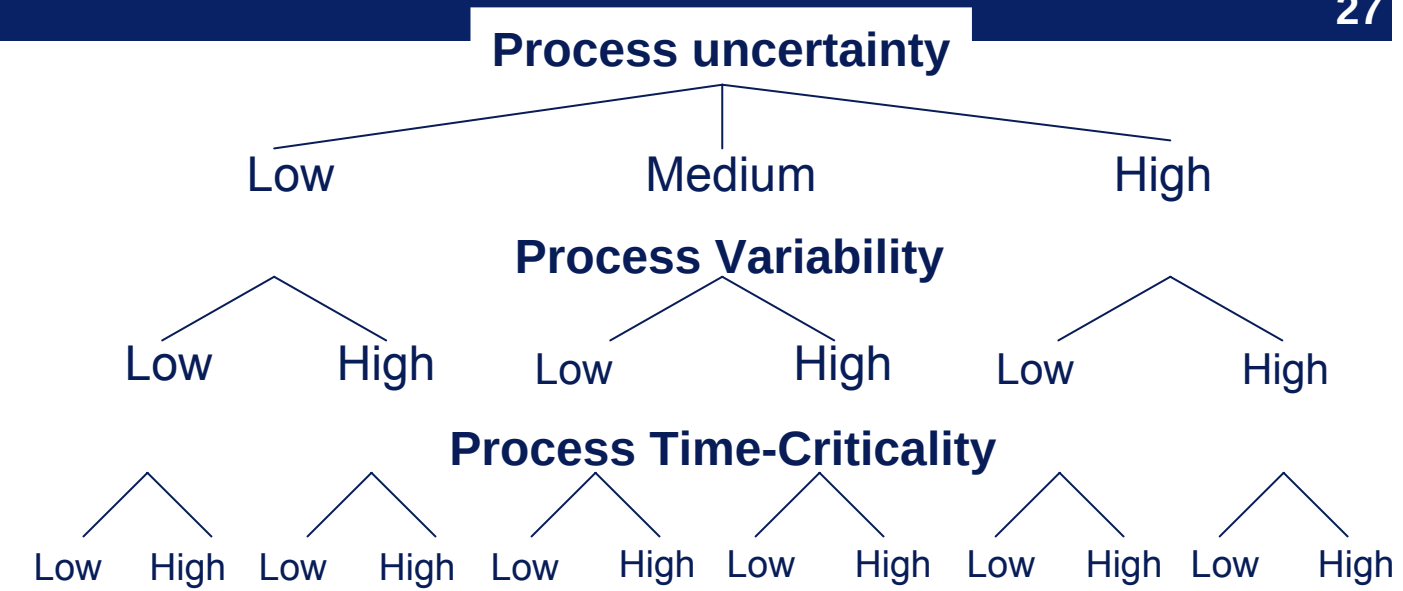
Propositions (4)

- **Proposition 4:** A business process characterized by **high time-criticality** and **low uncertainty** can be supported cost efficiently with an IS according to Propositions 1a and 1b, yet with a reduced but still sizable share of manual operations in the case of high variability.
- **Proposition 5:** A business process characterized by **high time-criticality** and **medium uncertainty** can be supported cost efficiently with an equal mix of flexibility-to-use and flexibility-to-change with a negligible share of manual operations, independent of the level of process variability.

Propositions (5)

- **Proposition 6:** A business process characterized by **high time-criticality** and **high uncertainty** can be supported cost efficiently with an IS according to Propositions 3a and 3b, yet with a reduced but still sizable share of manual operations in the case of high variability.

Model Results

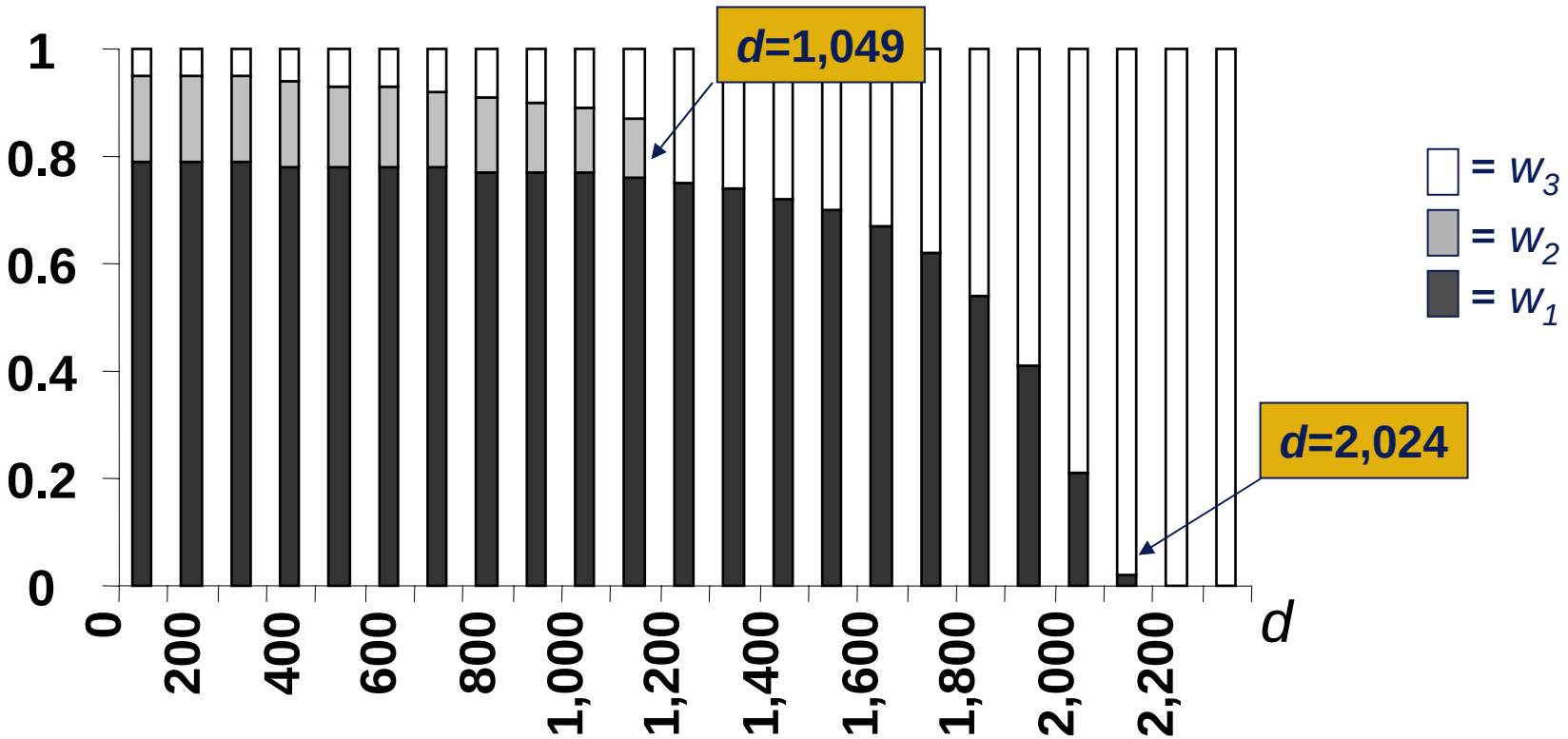


IS flexibility-to-use	+++	+++	+++	+++	++	++	++	++	+	+	0	0
IS flexibility-to-change	+	+	0	0	++	++	++	++	+++	+++	+++	+++
No use of IS	0	0	+	+	0	0	+	0	0	0	+	+

+++	for $w \geq 0.67$ (dominant IS flexibility strategy)
++	for $0.33 \leq w < 0.67$
+	for $0.10 \leq w < 0.33$
0	for $w < 0.10$

Sensitivity Analysis: Variation of System Operating Costs *d*

Cost assumptions: *a* = 100, *b* = 300, *c* = 50, *d* = **variable**, *e* = 300, *f* = 1,500, *g* = 0.7
Low uncertainty (*p* = 0.8), medium variability (*v* = 0.6), high time-criticality (*r* = 0.5)



Summary

- **Objective**: Develop a theory to determine the impact of IS flexibility on the cost efficiency of business processes
- **Main results**:
  - High uncertainty corresponds with IS flexibility-to-change
  - Low uncertainty corresponds with IS flexibility-to-use
  - High variability can limit the efficiency of the IS in general
  - High time-criticality can strenthen the efficiency contribution of the IS in general
- **In general**: IS-flexibility can help explain IS success

Applicability

- Establish the **general relevance of IS flexibility for IS management** and the benefits of longterm IS investment strategies.
- Contribution to **operationalization of flexibility-related process characteristics** (e.g., uncertainty, variability, time-criticality) that have been included in IS investment decisions already, albeit often implicitly.
- Contribution to **service- und release-management in software industry**; allows to better balance features included in the SW, and uprading possibilities.
- **Evaluation of IS-innovations** (web-services, outsourcing-arrangements) regarding flexibility aspects.

Next Steps

- **Empirical Evaluation** of variables and constructs (interface of *theory* and *research*)
- Concrete **operationalization of risk parameter**: flexibility-to-change as a real option
- Concrete **consideration of dynamic aspects**, including IS life time
- **Relaxation of various model assumptions** (e.g., cost disadvantage of processing activities outside of the IS)
- Development of **practically applicable design and management guidelines**, e.g., by operationalizing the weights of various IS flexibility components

Thank you very much for your attention –

Questions?