KNOWLEDGE MANAGEMENT STRATEGIES FOR NEW PRODUCT DEVELOPMENT

Gulru Ozkan, Cheryl Gaimon, Stylianos Kavadias
What is Knowledge Management (KM)?

- **Knowledge** embodies the skills, experience, contextual information and expert insights that provide a framework for evaluating and incorporating new information.
  
  *Davenport & Prusak (1998)*

- **Knowledge Management** refers to the collection of processes that govern the creation, dissemination, deployment and retention of knowledge.
Why is KM important?

- “The only real security that a man will have in this world is a reserve of knowledge, experience, and ability.”
  - Henry Ford, founder of the Ford Motor Company

- "In an industry with its entire foundation built upon R&D, I can’t think of anything more compelling than a solid KM strategy. It’s what will differentiate the winners from the losers.”
  - Claire Hogikyan, Senior Director of Intellectual Property, Pfizer
KM & New Product Development (NPD)

- NPD projects are the most knowledge-intensive endeavors of the modern corporation.
  - Macher 2005

- KM of NPD projects impacts time-to-market, product functionality, manufacturing costs, and match between customer needs and final product features.
  - Mihm 2003, Ulrich & Eppinger 2003

- Empirical: many firms do not know how to develop and exploit knowledge capabilities for successful NPD.
  - Doos et al. 2005
KM of Product & Process Design Teams

- How should manager ↑ levels of knowledge through:
  - Knowledge development (KD) of product design team
  - Knowledge transfer (KT) between teams (*incl. response*)

Rates of KD and KT are *dynamic decision variables* defined throughout NPD project.
Teams Embed Knowledge in Project

- During development, each team embeds its knowledge in NPD project.
Embedded Knowledge

Extent & timing knowledge is embedded → product attributes, process capabilities, and time-to-market.

What drives rates that product & process design teams embed knowledge?

- **KD & KT** to ↑ levels of each team’s knowledge which ↑ rates knowledge embedded
- **Errors** uncovered during **KD or KT** ↓ value knowl. previously embedded: **Relevant Knowl.**
Features of Model

- **KM** throughout **NPD** project: KD; KT both dir.
- **Effectiveness of KD and KT** are dynamic.
- Capture impact of **errors** uncovered while KD & KT → rework and engineering changes.
- Capture **uncertain** nature of NPD project outcome.
- Capture **time-to-market** considerations.
- Capture drivers of **net revenue** (margin)
- **Obj.** Maximize expected profit over NPD project.
Research Questions

- What drives mgr. strategy for KD product design team?
- What drives mgr. strategies for KT between teams?
- How should mgr. respond to errors uncovered by KD & KT?
- How should mgr. respond to uncertainty of successful product launch?
- How should mgr. respond to trade-off: early release for time-to-market benefits; delay launch to ↑ features & net revenue earned?
Related NPD Literature

Parallel devel.: find # & timing project reviews during devel. to min. time-mkt. Ha & Porteus (1995)

Partial overlap sequential prod→proc devel min time-mkt.;
Meeting frequency; info. batching: Loch & Terwiesch (1998)
Misaligned team incentives: Mihm et al. (2003)
Others include Roemer et al. (2000), Joglekar et al. (2001), Roemer & Ahmadi (2004)

Related NPD Literature: Uncertainty-Errors

Krishnan (1997): **Sequential** activities can be overlapped. 

**Uncertainty** on evolution of upstream info **exogenous**

Mgr. impacts uncertainty by **freezing** upstream design.

Loch and Terwiesch (1998) **Sequential** dependency.

Mgr. impacts uncertainty through **pre-communication**.

Roemer et al. (2000)

**Uncertainty** on evolution of upstream info **exogenous**

Mgr. **impacts accuracy** of upstream flow down by setting overlap duration.

All of above: **objective to minimize development time**.
Our Model in Relation to Literature

- Permit dynamic KD; KT (both directions)
- Do not assume dependency structure: outcome

- Capture dynamic effectiveness KD & KT
- Mgr. controls rate, timing & impact of errors.

- KM $\rightarrow$ prod. features, efficiency manuf...$\rightarrow$ prob. success in mkt., net rev. & time-to-mkt.
Level Product Team Knowledge: D(t)

Rate Knowledge Development: \( \gamma(t) \)
Level Process Team Knowledge: $M(t)$

Rates Knowledge Transfer: $\beta(t)$ & $b(t)$

$\uparrow$ Level product knowledge: $\beta(t)D(t)^{\rho_2}M(t)^{\rho_3}$

$\rightarrow$ Level process knowledge: $b(t)D(t)^{r_1}M(t)^{r_2}$
Dynamic Levels of Knowledge: $D(t)$ & $M(t)$

*Dynamic decisions:* $\gamma(t)$, $\beta(t)$, $b(t)$
Teams Embed Knowledge in NPD Project: X(t) & Y(t)

**X(t):** Cumulative *useful* knowl. embedded in *product* design through time t.

**Change in X(t) at t:**
- ↑ in relation to level product team knowl. at t,
- ↓ due to errors uncovered at t by KD & KT.

Errors render portion previous embedded knowl. ‘useless.’

\[ X_t(t) = D(t) - \theta_1 \gamma(t) - \theta_2 \beta(t) \]

**Y(t):** Cumulative useful knowl. embedded in *process* design...

\[ Y_t(t) = M(t) - \theta_3 b(t) \]
Expected Net Revenue: $F[X(t)]R[Y(t),t]$

Probability product launched at $t$ is successful in marketplace: driven by cumulative useful *product design knowledge* at $t$: $F[X(t)]$

Net revenue earned from product released at $t$: driven by cumulative useful *process design knowledge* at $t$; and *time-based competition*: $R[Y(t),t]$
Objective Function

\[ \int_{0}^{T} \{F[X(t)]R[Y(t),t] - C_1[\gamma] - C_2[\beta] - C_3[b]\}dt + \Phi_1X(T) + \Phi_2Y(T) \]

(1) Expected Net Revenue
(2) Cost of KD
(3) & (4) Cost of KT
(5) Future Value Cumul. Useful Knowl.
Result: Two Dynamic Strategies for KT or KD

FRONT LOADING STRATEGY

\[ \gamma, \beta \text{ or } b \]

DELAY STRATEGY

\[ \gamma, \beta \text{ or } b \]

\[ 0 \rightarrow T \text{ time} \]

\[ 0 \rightarrow t_{max} \text{ time} \]
Combinations of Solutions

3 decision variables; 2 possible strategies each; 8 combinations of dynamic strategies.

Analytic Result: Conditions that drive KT in one direction to delay also drive KT in other direction to front-load.

6 combinations of dynamic KT & KD strategies.
Literature One Direction: KT Product to Process Only

Analytic Results:

- *Always front-load KD*
- Either strategy for KT.
- Front-load KT if
  - M(0) small or D(0) large
  - large contribution net revenue from process knowl. or small contribution prob. success from product knowl.
- ...
Leveraging Product Design Knowledge

Suppose $D(0)$ is large, $M(0)$ is small.

$\gamma$, $\beta$ or $b$
Leveraging Process Design Knowledge

Suppose $D(0)$ is small, $M(0)$ is large.

$\gamma$, $\beta$ or $b$

$\gamma$: KD for product design team
$\beta$: KT to product design team
$b$: KT to product design team
Analytic Results on Error Detection

- If large rate of errors uncovered by KD or KT:
  - KD or KT is pursued at smaller rate
  - Peak KD or KT is delayed

- If large rate errors uncovered by KT:
  - KD is front-loaded  \textit{SUBSTITUTION}

- If large rate errors uncovered by KT in one direction
  - KT front-loaded other direction  \textit{SUBSTITUTION}
Analytic Results on Net Revenue

If process design knowl. is key driver net revenue:

- KD & KT (both directions) pursued at larger rates → COMPLEMENTARY

- Manager leverages process design knowledge:
  - KT to product design team is front-loaded
  - KD product team & KT to process design team delayed
Analytic Results on Prob. Success

If product design knowledge key driver probability successful launch

- KD & KT (both directions) pursued at larger rates
  \[ \Rightarrow \text{COMPLEMENTARY} \]

- Manager leverages product design knowledge:
  - KD product team & KT to process team front-loaded,
  - KT to product design team is delayed.
Contributions

- Holistic treatment KM & NPD
- Integration of knowledge **product & process** design teams
- **KD** along with **rate, timing and direction of KT**
  - without assuming dependency structure between teams
- **Front-loading vs. delay** strategies
- Impact of **errors** on KD and KT
- Impact of **uncertainty** & product design → success launch
- Impact of process design → **net revenue**
- Impact of **time-based competition**
Managerial Insights

- How mgr. should **assemble teams** at outset
- Importance **improving effectiveness** KT & KD
  - incentives for sharing knowl.
  - formal processes to codify and share knowl. (IT)
  - selecting team member (ability communicate & absorb)
- **Depth vs. breadth knowl.** (depth may ↑ M or D more; but may ↓ effectiveness KT)
- **Strategies for KD and KT also depend on**
  - errors: ↓ complexity & decompose vs. performance
  - external conditions (time-to-mkt.)
  - ability to drive expected net revenue