Knowledge Integration and Management of Innovation Projects

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The KITE research group

- Knowledge Integration and Innovation in Transnational Enterprise
- Responses to trends of desintegration in the economy:
  - Globalization of R&D, markets and manufacturing
  - Transformation of markets
  - Changes in the character of technological and scientific development
- Three research themes:
  - Knowledge Integration and Project Organization
  - Knowledge Integration and Outsourcing
  - Innovation and the Integration of External Knowledge
- 8-year Program (2007-2014), funded by Bank of Sweden Tercentenary Foundation
- 11 researchers (and recruiting)
- Directorate: Professor Christian Berggren and Associate Professor Fredrik Tell
- Webpage: [http://www.liu.se/kite](http://www.liu.se/kite)
Presentation outline

• Knowledge Integration and Innovation: the problem
• Integrating Knowledge in Product Development Projects
• (Knowledge Integration Challenges in Project-based Firms)
Why knowledge integration and innovation?

- Knowledge specialization increasingly important, as firms are increasingly multi-technological (Granstrand et al 1997; Brusoni et al, 2001)
- Knowledge integration is difficult (Dougherty, 1992; Hoopes and Postrel, 1999; Lindkvist, 2005)
- Knowledge integration important for performance (Piscitello, 2004; Brusoni et al, 2005; Nesta and Saviotti, 2006)
- Innovations as “new combinations” (Schumpeter, 1942) require integrative capabilities (Henderson and Clark, 1990)
What firms do

• Firms produce products and services
• To produce things firms need capabilities
• To be capable of producing, firms need to integrate knowledge
• Knowledge integration takes place under conditions of bounded rationality
Conceptions of Firms

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<th>Production</th>
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<td>Working paper Orthodoxy</td>
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<td>Bounded rationality</td>
<td>Evolutionary Economics</td>
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<td>Transaction Cost Economics</td>
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(Winter, 1988)
Governance/Organizational problem

• Problem of co-operation
  – Incentive alignment

• Problem of co-ordination
  – Knowledge integration
How to achieve cooperation?

• Firm as a nexus of contracts that unify property and decision rights
• Incomplete contracts (firms as failed markets)
  – Hierarchy – authority relationships
  – Reward sharing schemes (incentives)

“The key idea is to provide as focused, intense incentives as possible within the constraints implied by the corporate form and the interdependencies that it both creates and is meant to control. The key architectural elements involve redrawing the vertical and horizontal boundaries of the firm to increase strategic focus; creating relatively small subunits within the organization in which significant decision rights are lodged […].

Co-ordination problem

• How to integrate different knowledge bases for efficient production?

“Coordination means, at a minimum, that all the needed tasks are completed without pointless duplication. Better yet, it seeks to ensure that the tasks are done efficiently, by the right people, in the right way, and at the right time and place. Ultimately, full coordination also requires that the tasks undertaken are the right ones.”

How do firms produce new things?

• Through new combinations, Schumpeter told us…
• New combinations require integration of existing knowledge as well as generation of new knowledge
The problem of knowledge integration

• Knowledge specialization requires integration
• Knowledge complementarities
• Knowledge transfer is not always efficient

(Grant, 1996)
Achieving knowledge integration

• Some contingencies:
  – Knowledge differentiation and complexity (Grandori, 2001)
  – Interdependencies: pooled, sequential, reciprocal (Thompson, 1967; Grant, 1996)
  – Task features: frequency, homogeneity, causal ambiguity (Zollo and Winter, 2002)

• Integration mechanisms:
  – Hierarchy, rules, prices, property rights sharing, communication networks, knowledge integrators, teams, communities (Grandori, 2001)
  – Rules and directives, sequencing, routines, group problem solving (Grant, 1996)
  – Tacit experience accumulation, articulation, codification (Zollo and Winter, 2002)
Organizing for innovation

- New product development projects example of knowledge integration in innovative (although not always radical) settings
- How is knowledge integrated?
  - Knowledge integration in the development of complex products under time constraints (Lindkvist et al, 1998)
  - Knowledge integration through near decomposability in product platform projects (Yakob and Tell, 2007)
  - Integration of distributed knowledge in a new product development project (Enberg et al, 2006)
Projects and knowledge integration

• Projects as a separation strategy
• Projects as a device for dealing with non-repetitive tasks
• Projects are made up of temporary constellations of people
NPD in telecoms

- How is knowledge integrated in large and complex development projects?
- Concurrent engineering in NPD projects: Now (in operation 2006) and then (in operation 1994) in the telecom industry.
- Large development projects (>100 engineers)
- Follow up-projects on major breakthrough technologies
- Researched by retrospective, interview-based, qualitative case-studies
1990s NPD: Post GSM

- Digital cellular telephony system for a new important customer
- New standard partly based on GSM
- Software and hardware
- Half development time of GSM
- 1 country, >100 engineers, 2 years

Concurrent engineering (1)
## Analysis

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<th>Type of complexity</th>
<th>Error detection</th>
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<th>Error diagnostics</th>
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<td><strong>analyzeable</strong></td>
<td>Scheduling logic</td>
<td>Separating logic</td>
<td>Semi-coupling logic</td>
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<td>Coupling logic</td>
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Implications for knowledge integration

- High complexity but error detection rather than error diagnosis – Tightly coupled projects
- Tight knowledge integration
  - Practicing the processes
  - Solving problems due to interaction effects among units
  - Continuous feedback – little buffers
  - Less ‘work breakdown structure’ oriented
  - Arenas
    - Systems emergency ward
    - Daily meetings
    - Video/telephone conferencing
  - Combination of hierarchical and network structures
2000s: Post 3G platform

- Leading global telecommunications firm - develops, produces, supplies, and installs telecommunications systems
- n th version of third generation cellular telephone system
- Run partly in parallel with version n-1 and n+1 version
- Software platform (hardware negligible)
- 5 countries, > 200 engineers, 24 months
- (Mainly) Internal development and integration

Research problem

• Previous research particularly concerned with outcomes of platform development approaches rather than the process itself
  (e.g. Krishnan and Gupta, 2001; Muffato and Roveda, 2000; Meyer and Lehnerd, 1997)

• Previous research primarily dealt with complexity in platform development by modular approaches, assuming perfect decomposability
  (e.g., Ethiraj and Levinthal, 2004; Baldwin and Clark, 2000; Ericsson and Erixon, 1999)
Understanding Complex platform projects as nearly decomposable systems

“(1) In a nearly decomposable system the short-run behaviour of each component sub-system is approximately independent of the short run behaviour of the other components; (2) in the long run the behaviour of components depends in only an aggregate way on the behaviour of the other components” (Simon, 1996: 198)

“While decomposing a problem is necessary in order to reduce the dimension of the search space, it also shapes and constrains a search process to a specific sub-space of possible solutions thus making it possible for optimal solutions not to be ever generated and for systems to be locked into sub-optimal solutions” (Marengo, Pasquali and Valente, 2005: 3)
Perceived problems with previous ways of working

- Quality not up to standard
- Difficulties in adapting to emerging objectives and new specifications
- Time delays
Developing telecom platforms in work packages

- Starting early by defining small work packages (WP)
- Work out a genealogy of the project
- Set up interdisciplinary teams working with each package (teams of 10-15)
- Each WP is an entity in the anatomy (60-70 WP)
- Fairly brief “slots” for delivery from WP to systems integration (second weekly build)
- Continuous integration enabled by “build” environment tool
Ways of Working

Previously

This project
The Anatomy of a project
Development Pattern – Concurrent Engineering (ii)
Managing near decomposability

Search process
- System aggregation and knowledge integration
- Decomposition and (re)composition (cf. modularity)
- Learning dynamics of feed-back and feed-forward
Integration of distributed knowledge: The stacker NPD project

- Incremental, 1 country, 13 engineers, 2 years
- Not much of a shared goal
- Project members were not working tightly together
  - Located in different departments
  - Little communication
  - Met primarily at project meetings – but not in conducting their work
- Knowledge did not seem to be shared
- How did knowledge integration take place?

# Integrating Knowledge

## Traditional KM view

- **Codified** knowledge for simple tasks and standardized products
- **Tacit** knowledge for advanced tasks and customized solutions

(e.g., Grant 1996; Hansen et al 1999;)

## Alternative view

- Task features and knowledge integration
- Learning investment function
- Frequency
  - Articulation/Codification
- Homogeneity
  - Articulation/Codification
- Causal ambiguity (complexity)
  - Articulation/Codification

(Zollo and Winter, 2002)
# A process typology

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<th>Learning typologies, outcomes and economic benefits</th>
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<td><strong>Experience accumulation</strong></td>
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<tr>
<td>• Learning by doing</td>
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<td>• Learning by using</td>
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<td>• Local experts and experiential knowledge in individuals (e.g. subject matter expert)</td>
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<td><strong>Outcome</strong></td>
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<td>• Improved understanding of action-performance relation (predictive knowledge)</td>
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The Stacker case

Sarah
Responsible for technical requirements
Development department
MSc in engineering
Tenure: 2 years

John
Electro-design
Located at the IT department
Vocational training
Tenure: 2 years

Bill
Design engineer consultant
Located at the development department
BSc in engineering
Tenure: 2 years

Harry
Design engineer consultant
Located at the development department
Vocational training

Steven
Manufacturing, tripods and chassis
(sub-group at the manufacturing department)
Internal courses
Tenure: 25 years

Bill
Design engineer consultant
Located at the development department
BSc in engineering

Henry
Marketing
No formal education
Tenure: 30 years

Richard
Manufacturing, walkie
(sub-group at the manufacturing department)
BSc in engineering
Tenure: 2 years

Albert
Order structure builder
Manufacturing department
Co-located with Harry and Bill
No formal education
Tenure: 40 years

Paul
Technical support and field testing
(sub-group at the development department)
Vocational training
Tenure: 30 years

Anthony
Quality and standards
(sub-group at the development department)
BSc in engineering
Tenure: 4 years

Charles
Order structure builder
Manufacturing department
No formal education
Tenure: 17 years

Tom
Order and administration
Secondary school certificate
Tenure: 13 years

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Responsible for technical requirements
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Tenure: 2 years

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An iterative model of knowledge integration

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<td>Homogeneity</td>
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<td>Low</td>
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<td>Complexity</td>
<td>Low</td>
<td>High</td>
<td>High</td>
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<td>Knowledge integration mechanism</td>
<td>Experience accumulation</td>
<td>Articulation/ Codification</td>
<td>Iterative model</td>
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<th>Acting</th>
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<td>Parameter input</td>
<td>Contribution</td>
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<td>Experience sharing</td>
<td>Representation</td>
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<td>Ad hoc problem solving</td>
<td>Subordination</td>
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(Enberg, Lindkvist & Tell, 2006)
A more complicated case

Steam Turbines
When complexity increases…

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<th>Peripheral group</th>
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<tr>
<td>Experienced</td>
<td>Less experienced</td>
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<td>Arno (aero)</td>
<td>Alain (aero)</td>
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<tr>
<td>Leonard (aero)</td>
<td>Dieter (MI)</td>
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<tr>
<td>Lukas (MI)</td>
<td>Dominik (project manager)</td>
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<tr>
<td>Nikolaus (MI)</td>
<td>Franz (MI)</td>
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<tr>
<td>Urs (aero, project manager)</td>
<td>Marcel (MI)</td>
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<tr>
<td>Valentin (MI)</td>
<td>Simon (MI)</td>
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</tbody>
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…so does division of labor and the need for communication (articulation/codification)
Conclusions and discussion

• The integration of knowledge in NPD
  – Both sequencing and group problem solving
  – Both tacit experience and articulation/codification
  – Both collectively and individually

• Technology as one contingency
  – Complexity and degree of decomposability
  – Degree of novelty in relation to technological trajectories
Future research projects…

• Varying degrees of ”distributedness” of projects
  – Cognitively
  – Physically
  – Organizationally
• Varying degrees of complexity and novelty of projects
Learning in Project-based firms

- Experiential learning and firm capabilities
- Learning is difficult!
- Learning in project-based firms: an instance of learning from “samples of one or fewer” (March et al, 1991)?
- The role of codification in learning between projects
Knowledge integration problems in project-based firms

• Project and task oriented learning: neglect of organizational learning
• Lack of permanent organizational “knowledge silos”
• Dependent upon individuals
• Target oriented, but:
  – Lack of history
  – Lack of routines

(Prencipe and Tell, 201; Tell and Söderlund, 2001, Cacciatori, 2004)
Knowledge integration context in projects

- Low frequency (temporary tasks)
- Low homogeneity (unique tasks)
- High causal ambiguity (complexity)

- How is inter-project learning managed?
Research Method

• **Structured and unstructured questionnaire** to collect quantitative data (piloted with companies operating in three different industries).

• **Interview-based survey** with 50 companies carried out in UK, Sweden, Italy, Germany, Japan, and North America.

• **Selection of 6 pertinent cases**
Approaches to inter-project learning

- A firm’s *learning landscape* is defined as the mix of project-to-project learning mechanisms adopted and implemented. It reflects the multidimensional nature of a firm’s approach to project-to-project learning.
- Hansen *et al.* (1999): *Personalisation strategy* and *codification strategy* to knowledge management.
  - In firms that pursue a *personalisation strategy*, “knowledge is closely tied to the person that who developed and it and is shared to mainly through direct person-to-person contact” (p. 107).
  - A *codification strategy* would instead revolve around ICT-based technologies, “knowledge is carefully codified and stored in databases, where it can be assessed and used easily by anyone in the company” (p. 107).
Learning landscapes (1)

- **The explorers (or L-shaped) landscape.** Usually relatively small, these firms emphasised knowledge routinisation processes, knowledge transfer through people-to-people communication, and are characterised by a strong and receptive culture.

- **The navigator (or T-shaped) landscape.** Firms that implemented mechanisms for project-to-project learning based on knowledge articulation process. Their focus was on the implementation of these mechanisms not only at the individual and project levels but also, and mainly, at the organisational level.
<table>
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<tr>
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<th>Knowledge articulation</th>
<th>Knowledge codification</th>
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<tr>
<td><strong>Individual</strong></td>
<td>• On-the-job training</td>
<td>• Figurative thinking</td>
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Learning landscapes (2)

*The exploiters (or staircase) landscape.* Firms whose emphasis was on the deliberate attempt to codify and store knowledge developed during the execution of a project in documents so that it would become more easily accessible to and *exploitable* for the rest of the organisational members. These firms were already involved in the advanced development of ICT-based tools to *exploit* project knowledge.
## Exploiter’s learning landscape

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<tr>
<td><strong>Individual</strong></td>
<td>• On-the-job training</td>
<td>• Figurative thinking</td>
<td>• Diary</td>
</tr>
<tr>
<td></td>
<td>• Job rotation</td>
<td>• “Thinking aloud”</td>
<td>• Reporting system</td>
</tr>
<tr>
<td></td>
<td>• Specialisation</td>
<td>• Scribbling notes</td>
<td>• Individual systems</td>
</tr>
<tr>
<td></td>
<td>• Re-use of experts</td>
<td></td>
<td>design</td>
</tr>
<tr>
<td><strong>Group/Project</strong></td>
<td>• Developed groupthink</td>
<td>• Brainstorming sessions</td>
<td>• Project plan/audit</td>
</tr>
<tr>
<td></td>
<td>• Person-to-person</td>
<td>• Formal project reviews</td>
<td>• Milestones/deadlines</td>
</tr>
<tr>
<td></td>
<td>communication</td>
<td>• De-briefing meetings</td>
<td>• Meeting minutes</td>
</tr>
<tr>
<td></td>
<td>• Informal encounters</td>
<td>• Ad-hoc meetings</td>
<td>• Case writing</td>
</tr>
<tr>
<td></td>
<td>• Imitation</td>
<td>• Lessons learnt and/or post-mortem meetings</td>
<td>• Project history files</td>
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<tr>
<td></td>
<td></td>
<td>• Intra-project</td>
<td>• Intra-project lessons learnt database</td>
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<tr>
<td></td>
<td></td>
<td>correspondence</td>
<td></td>
</tr>
<tr>
<td><strong>Organisational</strong></td>
<td>• Informal organisational routines, rules and selection processes</td>
<td>• Project manager camps</td>
<td>• Drawings</td>
</tr>
<tr>
<td></td>
<td>• Departmentalisation and specialisation</td>
<td>• Knowledge retreats</td>
<td>• Process maps</td>
</tr>
<tr>
<td></td>
<td>• Communities of practice</td>
<td>• Professional networks</td>
<td>• Project management process</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Knowledge facilitators and managers</td>
<td>• Lessons learnt database</td>
</tr>
</tbody>
</table>
Conclusions

- Importance of process dimension of firms’ approaches to project-to-project learning.
- Distinguishing knowledge codification process as a cognitive effort led us to adopt the model suggested by Zollo and Winter (2000) based on the processes of experience accumulation, knowledge articulation, and knowledge codification.
- By relating these three processes to the individual, project, and organisational levels we developed a three-by-three matrix that enabled us to categorise the variety of mechanisms that project-based firms use.
- A firm’s learning landscape has been defined as the mix of project-to-project learning mechanisms that firms adopted and implemented.