Exploring the relationship between software development processes and IT based business innovation. A quantitative study in Norway

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Abstract

This paper investigates the relationship between software development methods and business innovation. Two hypotheses were tested; one that assumes that IT-based business innovation can be planned and managed as a part of a top-down strategy, and one that assumes that innovation is basically emergent and unmanageable. A pilot survey was done in the Norwegian software industry, using a web-based questionnaire. 123 companies responded, from a total population of 610.

We find that neither the top-down business planning approach, nor the emergent "amethodical" view is supported. Instead we find that the innovative projects are associated with the use of adapted development methods or various techniques. Innovative projects are neither initiated from top management nor improvised; they are usually initiated at department level. Further, our findings suggest that they occur predominantly in young companies.

We interpret these findings within a resource based innovation view: IT-based business innovation is best supported by local initiatives in a competent environment, using locally adapted techniques.

Keywords: *Formal systems development method, IT based business innovation*

Introduction

In the past ten years there has been an increasing interest in technology based innovation, both in the research communities and in national policy-making. The main reason, on the national level, is the assumed impact of technology on economic growth rates. On a business level the ability to innovate is seen to be crucial for companies to survive in the global market place.

In the 1990s the tremendous potential of Internet technology significantly changed the ways we combined technology and business to innovate, and also our vision of what was

possible. Subsequently, the history of the dot com crash in 2001 taught us some important lessons.

- First, technology in itself cannot provide competitive advantage. As IT has become a wide-spread commodity; its importance for business performance is increasing, but its importance to competitive advantage is decreasing (Carr 2003).
- Second, the nature of IT based innovations seems to be elusive. After the initial frenzy, both the BPR and the dot com booms faltered. Many companies tried to learn from the early innovators, like Amazon and eBay, without much success.

This implies that we need to understand better several aspects of IT-based innovations. A basic question is: Can IT-based business innovation be planned and managed?

There are two opposing views on this question. The first view is prevalent at business schools, and assumes that IT-based business innovations are the results of careful analysis, strategic positioning and managed implementation (Porter 2001, Davenport 1993, Laudon and Laudon 2004). The second view assumes that innovation is basically creative, emergent and unmanageable in a business context. Echoing Schumpeter, the American economic historian Mokyr put it this way: "Technological creativity, like all creativity, is an act of rebellion" (Mokyr 1992).

It is probably useless to try to answer this question on a general level, because there are too many contingency factors that influence innovation. But we think it makes sense to investigate the question on a more limited scale. We define IT-based business innovations to be a combination of software and business process change resulting in new business concepts or improved business performance. In an information systems development context this change process may be managed by structured development methods, or it may be done on an ad hoc basis. Thus, it is interesting to investigate whether successful innovation is associated with structured information systems development methods, or - oppositely - with ad hoc initiatives.

Therefore, the research question we try to give some preliminary answers in this pilot study is:

- What is the relationship between software development processes and IT-based business innovation?

The rest of the paper is structured as follows. In the next two sections we present our hypotheses and discuss the key terms of business innovation and software development methods. Then we present our research approach, followed by a presentation of our findings and a discussion in the following section. Lastly, we conclude and suggest directions for further research.

Hypotheses

In this section we present our two competing hypotheses, one based on a top-down planning view, and one based on an emergent view.

Alternative 1: IT-based business innovation can be planned and managed

From a business perspective a top-down innovation approach is well documented in the Strategic Information Systems research stream (Laudon and Laudon 2004), emphasizing how planned IT-enabled business innovation can be used to achieve competitive advantage.

This approach is reflected in most of the standard software development methods: Information systems projects should be anchored in a business and product strategy (Tabrizi and Walleigh 1997), and start with a top-down business analysis (Jacobson et al. 1999, Stapleton 2003). Failed projects are explained by being technology-driven and lacking a clear and structured process (Cadle and Yeates 2004).

Building on this perspective, we suggest the following hypothesis:

H1: A high degree of innovation is associated with a high degree of development process structure, given high formal product development process.

Alternative 2: IT-based business innovation is emergent

In a series of case studies of large corporate information infrastructures, Ciborra (2000) found that although the management literature recommends a top-down approach, the evidence for the viability of this approach is scarce. On the contrary, the authors document that business innovation is often the result of technological drift and unintended consequences.

There are various reasons for this drift. One is that established business models and practices are badly suited to innovation (Christensen and Overdorf 2000). Another is that the dynamics of IT-based business development are not easily controlled by traditional management and development methods (Truex et al. 2000), and tend to develop more through "tinkering and bricolage" (Ciborra 2002). From this perspective we suggest the alternative hypothesis:

H2: A high degree of innovation is associated with a low degree of formal development process structure.

Key terms: IT-based business innovation and development methods

In this section we define and discuss our key terms.

IT-based business innovation

IT-based innovation has been studied extensively for two decades, but there is hardly a consensus on how to define it. Some important contributions are:

- *Diffusion of innovations theory* (Rogers 1995), describing the diffusion pattern of an innovation in a user community.
- *The mutual adaptation of technology and business* (Leonard-Barton 1988), stating that the real innovation is the unique and mutually adaptive implementation in an organisation.
- *Process Innovation* (Davenport 1993), describing IT-enabled business process reengineering.
- *The IS Innovation Framework* (Larsen 1998), synthesizing innovation research in the three phases of ideas, creation and usage, focusing on the human activity system.
- Disruptive innovation (Christensen and Overdorf 2000), emphasizing the fundamental difference between sustainable and disruptive innovation.

These contributions all emphasize that the organisation is as important, or more important, than the technology. Building on this insight we choose a relatively simple definition: At the core of IT-based business innovations is the combination of a new technology with a new or changed business process. Following Evans (2003) we use the following criteria. We take the use of new, enabling technologies, like web, java, microsoft.net, web services, and peer-to-peer technologies to indicate technological innovation. Further, to measure business innovation we take novelties and changes in

- business processes
- supply chains
- knowledge management
- customer relations

as indicators for the degree of business innovation. And lastly, we take *combinations* of technological innovation and business innovation to be a particularly strong indicator of IT-based business innovation. For details, see table 9.

Development methods

To investigate our hypotheses, we measure the connection between IT-based business innovation and development methods. Building on earlier research (Fitzgerald 1998, Fagerstrom et al.2003) we assume that the majority of the companies use their own development method, that a minority of the companies use standard development method like RUP (jacobson et al. 1999) and XP (Stapleton 2003), and that some companies do not use methods at all. Further, we assume that many companies use *elements* from formal methods, adapted to their own environment.

Research approach

This section begins with a detailed description of the sampling and sampling design that was used, followed by how the research design and analysis of survey responses are determined. In the end, sample validity and non-response bias are discussed.

Sampling

Ideally, all companies involved in software development in Norway should be defined as the population for this research. This includes general private companies and public organisations as well as professional companies within the IT sector.

However, the two last year's research (Bygstad et. al. 2002 and Fagerstrøm et. al. 2003) showed that it is very hard to get responses from the general private and public businesses. As a result, this evaluation includes only professional IT companies (IT consultants and professional software development companies) in the population. This population is limited by three different Norwegian industrial classification (IC) codes:

7220000 (System- and software consulting),
7260001 (IT consulting) and
7260003 (IT services).

Based on experiences from last year's research (Fagerstrøm et. al. 2003), and in order to facilitate trend analysis and comparison with last year's survey, only companies with 5 or more employees and a valid contact person were considered. There were in total 1007 such companies in May 2003. All the companies were telephoned and asked whether or not they were actually involved in system development, reducing the total population to 627. Of these, 287 responded in the survey. In May 2004 the same 287 companies were contacted and were asked if they wanted to participate in this year's survey. 204 companies agreed to participate.

Research design

The survey was based on a questionnaire and implemented electronically by using the QuestBack system[1]. This system is based on e-mail distribution of a link to the actual survey and replies via a web browser on the internet. E-mail addresses were collected during the process of calling all companies in the survey sample. The QuestBack system has an automatic reminder, which was scheduled three or four times to those who had not responded after the request to participate in the survey was sent out. In this process, a number of respondents withdrew from the survey (by sending a separate mail), others just didn't reply. Also, there were some errors in the e-mail addresses, which were returned by QuestBack or external e-mail servers. After about eight weeks the survey was closed with these results:

Table 1. Sample segments when survey was closed

[1] www.questback.com

Group	Size	
Companies that agreed to participate	204	
1. Actual number of replies	123	60 %
2. Not answered	61	30 %
3. Withdrawn	20	10 %

Sample validity and non-response bias

Non-responses can be attributed to two primary reasons:

1. No answer – The respondent agreed to participate, but did not do so
2. Withdrawn – The respondent withdrew after having read the questionnaire

Our total population (companies which actually are involved in software development) can be estimated to around 627 companies. Thus, the response rate is 19,6 %. The results (estimated percentages for the total population) of the survey should be accurate to a level of plus or minus 8 %.

Findings

This section presents the results from the survey, and is divided into four parts: (1) type of IT project that the respondents selected to be the basis for answers in this survey, (2) development methods that had been used in the selected IT project, (3) degree of innovation and (4) degree to which product development is anchored in a product strategy.

Selected IT projects

Respondents were asked to choose one important IT project that has been accomplished the last year.

Table 2. Chosen IT project that has been accomplished the last year.

Selected IT project	Frequency	Percent
In-house SW development	58	47,2
SW development for customer	35	28,5
In-house adaption/implementation of standard SW	6	4,9
Adaption/implementation of standard SW for customer	16	13,0
Other	8	6,5
Total	123	100,0

In table 2 we can see that most of the projects selected by the respondents are in-house software development IT project – 47,2 percent chose this type of IT project. It is important to have this in mind when reading the rest of findings and discussion in this paper: This implies that in some cases the innovation is done within a technology firm

(in-house), in other cases it is the result of a shared project between SW company and their customer.

Development methods

Responses to the question to describe which development methods were used in the selected IT project are given in Table 3.

Table 3. Development methods that were used.

Development methods	Frequency	Percent
Standard SDM (e.g. RUP, MSF)	9	7,3
Adapted SDM	13	10,6
Own (or consultant's) method	39	31,7
A combination of techniques	41	33,3
No method	21	17,1
Total	123	100,0

Table 3 shows that most of the companies in this survey use a combination of techniques (33,3 %) in the IT project that they selected to be basis for answers in this survey. Only 7,3 % use standard system development methods e.g. RUP, MSF. These results are consistent with our findings in a previous survey (Fagerstrøm et.al. 2003), and other finding within this research field (Fitzgerald 1998).

Degree of innovation

To measure the degree of innovation in the IT project we asked the respondents to estimate the degree of innovation related to: (1) technology, (2) business processes and (3) outcome of the particular IT project that was selected.

Table 4. Innovation related to technology.

Technology	Frequency	Percent
Web	63	51,2
Java or J2EE	30	24,4
Microsoft.net	45	36,6
Web services	37	30,1
Peer-to-peer services	4	3,3
Other	44	35,8

The percent of technology that was used are greater than 100 % because the respondent was able choose one or more of the alternatives. From table 4 we can see that Web and Microsoft.net are widely used by the companies in this survey. It may be somewhat surprising that only four companies say that they use peer-to-peer services technology.

As table 5 shows 35,8 % of the respondents say that the selected IT project caused no change of business processes, while 51,2 % (adding the other categories) say that the IT project resulted in completely new business model or change in parts of the business model.

Table 5. Innovation related to changes in the business processes.

Change in the business processes	Frequency	Percent
Completely new business model developed	18	14,6
Supply chain are changed	9	7,3
New solution for knowledge management	12	9,8
New/changed solution for customer relations	24	19,5
No change of business processes	44	35,8
Other	11	8,9
Missing	5	4,1
Total	123	100,0

Table 6 shows that around half of the projects are focused on IT-based business innovation (combinations of new technology and business change), while the other half are purely SW projects

Table 6. Outcome of the particular IT project.

Outcome of the particular IT project	Frequency	Percent
New version of existing software	45	36,6
Completely new software	19	15,4
New/changed SW and improved business process	30	24,4
New/changed SW and new business process	10	8,1
New/changed SW and new business concept	13	10,6
Other	3	2,4
Missing	3	2,4
Total	123	100,0

Anchoring in a product strategy

To be able to measure the degree of anchoring in a product strategy we asked the respondents to estimate: (1) if the project was a isolated project or part of product or business development, and (2) how formally the project was related to a product development process.

Table 7. Relation to a product or business development process.

Relation to a product strategy	Frequency	Percent
Isolated project	36	29,3
Part of product- or business development	87	70,7
Total	123	100,0

We can see in table 7 that the majority (70,7 %) of the projects were related to a product development process. A follow-up question to the respondents who said that the project was related to a product development process (n=87), yielded the results shown in table 8.

Table 8. Degree of relationship to a product development process.

Degree of relation to a product development process	Frequency	Percent
Ad hoc	3	3,4
Part of commission	29	33,4
Initiated by product development department	41	47,1
Overall product development process	13	15,0
Don't know	1	1,1
Missing	0	0,0
Total	87	100,0

From table 8 we can see that 33,3 % of the IT projects were part of a commission and 47,1 % initiated by product development department. Few respondents (only 3,4 %) say that the project was a result of an ad hoc situation.

Discussion

This section presents our key findings related to the hypotheses, and discusses the implications.

Innovation index

To measure the association between IT-based business innovation and development method, an innovation index was constructed from the variables introduced earlier, consisting of the following weighted elements:

Table 9. Innovation index

Category	Variable	Weight
• **Technology**	- Web technology	**1**
	- Java (or J2EE)	**1**
	- Microsoft.net	**1**
	- Web services	**1**
	- Peer-to-peer services	**1**
	- Other	**0**
• **Business innovation**	- New business model	**5**
	- Changed supply chain	**3**
	- Knowledge management solution	**3**
	- Customer Relation Management	**3**
	- No change of business process	**0**
• **Combinations of technical and business change**	- New version of existing software	**1**
	- New software	**2**
	- New software and business process improvement	**3**
	- New software and new business process	**4**
	- New software and new business model	**5**

The elements were summarized for each respondent, giving each project an *innovation index* with a minimum score of 0 and a maximum score of 15. This variable is converted to an *innovation level* according to table below.

Table 10. The relation between Innovation index and Innovation level

Innovation level	***Innovation index*** **from – to**	
low	0	3
medium	4	7
high	8	15

The *Innovation level* variable was constructed with the aim of distributing the *Innovation index* with as close as possible to one third of the observations for each of the three levels (low, medium and high): thus creating a *relative* innovation level between the companies in the survey. This was cross-tabulated with three categories of development methods:

- Formal methods: Formal methods, such as RUP, XP and including methods from consultancies
- Adapted method: Adapted formal method + use of various of techniques
- No method: No use of method

Table 11: Innovation level and development method

Develoment Method	--------- Innovation level ---------- Low	Medium	High	Total
Formal	10 (21,3%)	**28 (59,6%)**	9 (19,1%)	47 (100%)
Adapted	11 (20,4%)	19 (35,2%)	**24 (44,4%)**	54 (100%)
No method	**10 (52,6%)**	4 (21,1%)	5 (26,3%)	19 (100%)
Missing				3 (100%)
Total	31 (25,8%)	51 (42,5%)	38 (31,7%)	123

As table 11 shows formal methods are associated with a medium degree of innovation, adapted methods with a high degree of innovation, and no use of methods is associated with a low degree of innovation.

At this stage it is reasonable to ask whether there is different innovation level related to in-house development and development for an external customer. Table 12 shows that there are no significant differences between in-house and external projects.

Table 12: Cross table of SW development category and innovation level

Software development category	--------- Innovation level ---------- Low	Medium	High	Total
In-house SW development or adaption/implementation of standard SW	17 (26,6%)	27 (42,2%)	20 (31,2%)	64 (100%)
SW development or adaption/implementation of standard SW for customer	10 (20,5%)	22 (44,7%)	17 (34,8%)	49 (100%)
Other	4 (57,2%)	2 (28,6%)	1 (14,2%)	7 (100%)
Missing				3 (100%)
Total	31 (25,8%)	51 (42,5%)	38 (31,7%)	123

Our first hypothesis was:

H1: A high degree of innovation is associated with a high degree of development structure, given high formal product development process.

As seen in table 11 formal methods are associated with a medium degree of innovation. We also hypothesized a stronger association with innovation when the use of formal methods was part of an over all product development process. This was tested in table 13, and the result is negative. Thus, there is no support for hypothesis 1.

Table 13. Formalisation of the product development process related to the innovation index.

Formalisation of the product development process	Innovation index Mean	N
Ad hoc	8,0	3
Part of commission	6,3	28
Initiated by product development department	5,5	41
Overall product development process	5,1	13
Total	5,8	85

As seen in table 13 the innovation index declines as formalisation of the product development process increases.

Our alternative, second hypothesis was:

H2: A high degree of innovation is associated with a low degree of formal development process structure.

As seen in table 11, most of the projects that use no method have a low degree of innovation. It is hard to see any traces of creative and innovative "amethodical" development. Thus, there is no support for this hypothesis.

Adapted methods, techniques and innovation

Although we found no support for either hypothesis, we have identified a relevant finding. As table 11 shows, there appears to be an association between the use of adapted methods and techniques, and project innovation. The innovative projects use a collection of techniques or customised development methods.

How do we explain this finding? Unfortunately, our data do not provide more information on this revelation. However, the literature offers at least two possible explanations.

First, it may be explained from a resource based view (Andreu and Ciborra, 1996): An innovation is the result of tangible and intangible resources, performed - and often improvised - by clever people that possess a certain combination of skills and ideas. In an IT-based context this implies that innovators would use parts of development processes and techniques, and adapt them to the actual challenge. This is an important resource for innovations, because these skills are integrated as a part of the core competence in the firm (Barney 1991). In a way, this transfers the research question into knowledge management theory

Second, it may be assumed that the opportunity to experiment and adapt methods is associated to smaller and younger firms, where formalism is less rigid. Table 15 gives

some support to that assumption, in the sense that the younger the firm, the stronger is the innovation index of the project

Table 15. Company age and innovation level

Age of company	--------- Innovation level ----------			
	Low	Medium	High	Total
Young < 5 years	3 (14,3%)	8 (38,1%)	**10 (47,6%)**	21 (100%)
Medium 5-9 years	8 (17,4%)	19 (41,3%)	**19 (41,3%)**	46 (100%)
Mature 10-14 years	8 (32,0%)	12 (48,0%)	5 (20,0%)	25 (100%)
Old > 15 years	12 (42,9%)	12 (42,9%)	4 (14,2%)	28 (100%)
Missing				3 (100%)
Total	31 (25,2%)	51 (41,4%)	38 (30,8%)	123

Limitations

We acknowledge that there are limitations within this pilot study. Evans' criteria to measure innovation may be critisized for putting too much emphasis on what may be regarded as current technology and business fads. Empirically, however, our findings in the survey confirm the focus on these technologies and business trends in the software industry.

We also realize that our technology index may be questioned, both on its constructs and its weighting. The same applies to our grouping of systems development methods. However, the results are not significantly changed when these indexes are composed differently or given another weighting.

External validity may be questioned because our sample - for practical reasons - includes only SW development companies. Since over half of the projects are in-house in these companies, it may be argued that our results are valid only for this population. There are, however, no significant differences in the degree of innovation between the internal and external projects, as shown in table 12.

Finally, the analysis of the innovative projects could have been improved by asking for more contextual information from the respondents.

Conclusion

This is a pilot study, investigating the relationship between IT-based business innovation and software development methods. In a quantitative survey 123 companies were asked to identify an important development project last year, and describe attributes of that project.

We find that neither the top-down business planning approach, nor the emergent "amethodical" view is supported. Instead we find that the innovative projects are associated to the use of adapted development methods or various techniques. Innovative

projects are neither initiated from top management nor improvised; they are usually initiated at department level. Further, they occur in young companies.

We interpret these findings within a resource based innovation view: IT-based business innovation is best supported by local initiatives in a competent environment, using locally adapted techniques.

Further research should collect more data on the nature of this local competence environment, and also of more contextual factors, like top management support and financing issues. Ideally, a quantitative study should have an international focus, with data from more nations. Another track could be a more qualitative study, concentrating on a few case projects to study IT-based innovation over time.

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References

Andreu R. and Ciborra, C. (1996) "Organisational learning and core capabilities development: The role of IT", *Journal of Strategic Information* Systems 5, pp.111-127.

Barney, J (1991) "Firm Resources and Sustained Competitive Advantage", *Journal of Management*, 17, 99-120

Bygstad, B., Fagerstrøm, A., Østensen, T. (2002). *"Vi bruker vår egen metode, og den fungerer utmerket". En undersøkelse av hvilke utviklingsmetoder som er i bruk i norske programvare utviklingsmiljøer"*, Proceeding of Nokobit, Kongsberg.

Cadle, J. and Yeates, D. (2004) *Project Management for Information Systems*, Prentice Hall.

Carr, N. (2003) "IT Doesn't Matter", *Harvard Business Review*, May.

Christensen, C. M., and Overdorf, M. (2000) Meeting the Challenge of Disruptive Innovation. Harvard Business Review 78(2):66-76.

Ciborra, C. (2002). *The Labyrinths of Information: Challenging the Wisdom of Systems.* Oxford University Press

Davenport, T. H. (1993). *Process Innovation.* Boston, Ernst & Young.

Evans, N.D. (2003). *Business Innovation and Disruptive Technology*. Prentice-Hall.

Fagerstrøm, A., Bygstad, B., Østensen, T. (2003) "Adoption of Systems Development Methods and Market Orientation: An Empirical Investigation in Norway", *Proceedings of NOKOBIT, Oslo.*

Fitzgerald, B. (1998 A). "An empirical investigation into the adoption of systems development methodologies." *Information & Management*, Vol. 34, pp. 317-328.

Jacobson, I., Booch, G. and Rumbaugh, R. (1999) *The Unified Software Development Process*, Addison Wesley, Reading.

Larsen, T. J. (1998). "Information Systems Innovation: A Framework for Research and Practice". In Larsen and McGuire (eds.): *Information Systems Innovations and Diffusion: Issues and Directions*, Hershey, PA:,Idea Group Publishing, pp. 411-434.

Laudon, C. K. and Laudon, J.P. (2004). *Management Information Systems.* Upper Saddle River, New Jersey, Pearson Education.

Leonard-Barton, D. (1988). " Implementation as Mutual Adaptation of Technology and Organization." *Research Policy* Vol. 17(5), pp. 251-267.

Mokyr, J. (1992). *The Lever of Riches: Technological Creativity and Economic Progress*. Oxford University Press.

Porter, M. E. 2001. "Strategy and the Internet". *Harvard Business Review* (March), pp.63-78.

Rogers, E. M. (1995). *Diffusion of Innovations*, Fourth edition, Free Press.

Stapleton, J. (2003) DSDM: *Business Focused Development*. Addison-Wesley.

Tabrizi, B. and R. Walleigh (1997). "Defining Next-Generation Products: A Inside Look", *Harvard Business Review*, pp.117-124.

Truex, D., Baskerville, R., and Travis, J. (2000). “Amethodical Systems Development: The Deferred Meaning of Systems Development Methods”, *Accounting, Management and Information Technology*, Vol.10, pp. 53 - 79.