IS PROCESS INNOVATION EVOLUTION IN ORGANISATIONS

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ABSTRACT

This study identifies how Information System process innovations' (ISPIs) were evolved in three organisations using a sample of 124 internally developed ISPIs over a period that spanned four decades.

The four distinct time generations analysed are early computing (1954-1965); main frame era (1965-1983); office computing era (1983-1991), and distributed applications era (1991-1997). These follow roughly Friedman's and Cornford's categorisation of IS development eras. Four categories of ISPI's are distinguished: base line technologies (T), development tools (TO), description methods (D), and managerial process innovations (M).

ISPI evolution in the three organisations is characterised with two types of modifications based on Tolvanen's (1998) local method development framework: the degree and frequency of modifications. The degree of ISPI modification defines how large the changes are that are made to the local ISPI to improve its applicability. The frequency of ISPI modification explains how often an ISPI is changed.

For each era the variation between the modifications in the four ISPI categories is analysed. The analysis shows that within the organisations, the degree of ISPI modifications and the frequency of ISPI modifications varied significantly in the ISPI categories. The variation can be partly explained by differences in the development environments, differences in ISPI categories, and the differences in the organisations.

Keywords: Empirical research, Longitudinal Study, IS Process Innovations, degree of ISPI modification, frequency of ISPI modification

INTRODUCTION

One type of innovation, called here Information System (IS) Process Innovation has become important for organisational effectiveness. IS process innovation (ISPI) is defined here as any new way of developing, implementing, and maintaining information systems in an organisational context (Swanson, 1994).

IS development (ISD) can be described as a change process, which aims at improving and changing a present information system (IS) or implementing a new information system. IS process innovations (ISPIs) on the other hand play a major role in changing the information system development (ISD) process in organisations, and they can improve the process and outcomes of information systems. In the context of our paper we consider that a specific ISPI is chosen for use at a specific ISD project.

Our ISPI definition is relatively broad and covers a wide range of innovative activity within IS development. First, an ISPI can embrace changes in the technologies that offer new computing functionality or novel non-functional features (like portability, security) for the delivered IS. Typical technological innovations include adoptions of programming languages or operating systems. ISPIs can also include administrative innovations, such as the deployment of project management methods, the introduction of participative approaches to guiding development interactions, or the contracting of development work outside. In Swanson's terminology, ISPIs thus cover thus both technological (Type Ia) as well as administrative innovations (Type Ib) (Swanson, 1994).

Both administrative and technological innovations can be further classified into two sub-categories. In the administrative ISPI category we distinguish between management innovations (M) and description innovations (D). Within the technological innovations, we separate between tool innovations (TO) and core technology innovations (T). The motivation for such classification is that most of the IS development literature clearly distinguishes between organisational innovations (like project management principles, programming teams, extreme programming) and notational innovations (like the development of UML, method engineering and so forth). Some ISPIs specifically address the need for software engineering task improvement or advance core technologies including programming languages or data base management systems.

Management innovations (M) embrace changes in rules and administrative processes that improve, control, manage and co-ordinate development activities. Examples of managerial innovations are project management guidelines or organisational arrangements, such as chief programmer teams (Swanson, 1994). Description innovations (D) include changes in notational systems and standards, which are used to describe and communicate development products or processes between different stakeholders. Such innovations include the adoption of standardised modelling techniques like Data Flow Diagrams or Unified Modelling Language (UML). Some ISPIs-especially within description and managerial innovations- have long life spans. Cases in point are the more abstract concepts of decomposition and structured design or the idea object orientation (Fichman and Kemerer, 1993). Such ISPIs create cumulative paths within organisations that over time solicit incremental flows of complementary innovations, which center on a focal "starting" ISPI. Some ISPIs can thereby induce disruptive innovations into ISD processes as they fundamentally change the nature of the problems and design spaces they impose (Lyytinen and Rose, 2003).

Tool innovations (TO) include capital-intensive software assets such as application generators, CASE tools, documentation tools, data dictionaries, etc. They may also include mundane technologies that range from desktop publishing software, GroupWare applications to indexing software. Core technologies (T) consist of improvements in technical platforms that are critical to delivering the IS products and include, among others programming languages, database management systems, telecommunication software, middleware frameworks, etc. These ISPIs often have a short life expectancy and thus suggest a continued pursuit of innovation.

One aspect in ISPI evolution is the dynamics in the development practices, i.e. how the set of ISPIs used changes over time in locales (Friedman and Cornford, 1989). Based on Friedman and Cornford (1989) ISPIs are classified into several eras. Friedman and Cornford (1989) point out- based on an extensive empirical analysis of the historical evolution of IS development- that the four categories of innovations discussed above are often closely "horizontally" related, and they can be accordingly classified into a set of evolutionary generations. Shifts between generations in Friedman's and Cornford's analysis are caused by: 1) changes in hardware and software (T/TO innovations), 2) changes in types of systems being developed i.e. harnessing computing capability into untried organisational domains and tasks (what Swanson (1994) calls type II and type III IS innovations, respectively); and resulting in 3) changes in types of users. The latter two form external pull factors that drive the content and scope of ISPIs within each generation.

In this study four ISPI generations are recognised over a 43 year time period starting from the year 1954. The first generation (from the late 1940s until the mid 1960s) is largely hampered by "hardware constraints", i.e. hardware costs and limitations in its capacity and reliability (lack of T innovations). The second generation (from the mid 1960s until the early 1980s), in turn, is characterised by "software constraints", i.e. poor productivity of system developers and difficulties in delivering reliable systems on time and within budget (lack of D, M, and TO innovations). The third generation (early 1980s to the beginning of 1990s), is instead driven by the challenge to overcome "user relationships constraints", i.e. system quality problems arising from inadequate perception of user demand and resulting in inadequate service (lack of M, D, and TO innovations). Finally, the fourth generation (from the beginning of 1990s) was affected by "organisational constraints" (lack of M and D innovations). In the latter case the constraints arose from complex interactions between computing systems and specific organisational agents including customers and clients, suppliers, competitors, co-operators, representatives and public bodies (Friedman and Cornford, 1989).

In addition to above concepts an important concept defined is development units. Development units are generally: "regions involved as part of the setting of interaction, having definite boundaries, which help to concentrate the interaction in one way or another" (Giddens, 1984, p. 375). Our definition is purposefully loose in that a development unit may comprise of a single formal organisational unit, or several units; or a half of a unit, if such a unit is the target of the development behaviour. A focal point in distinguishing a development unit is the assumed scope within which the people are expected to develop an ISPI, or know about it. We denote development units as locales.

After Tolvanen (1998) ISPI evolution is defined as how the general ISPI modifications affect ISPI development relevant to the ISD situation in hand. Tolvanen (1998), Harmsen et al. (1994a, 1994b), and Hardy et al. (1995) defined two dimensions of ISPI modifications as follows. The first dimension, the degree of ISPI modifications is defined as how large a change is required to the local method to improve its applicability (Tolvanen, 1998; Harmsen, et al., 1994a, 1994b). The second dimension, the frequency of ISPI modifications explains how often a method needs to be changed (Hardy et al., 1995). More specifically, it measures how often changes in the ISD situations are reflected in the methods (Tolvanen, 1998).

Wynekoop and Russo (1993) argue even though the organisations' local methods are relatively common it is not known why and how organisations develop their methods, or how frequently methods are refined or updated. An effort has been made to identify evolution paths between different types of methods or even to construct a family tree of methods (Smolander et al. 1989). A survey of method's historical evolution can be found from Tolvanen (1998). Tolvanen (1998) argues that the methods must be viewed from an evolutionary perspective by analysing how organisations develop their methods. Tolvanen (1998, p. 59) characterises the local method development with the degree of and the frequency of modifications (Figure 1). Examples of local method development efforts can be found from Tolvanen's (1998) study (see Table 1).

Figure 1. Two dimensions of the local method evolution: the degree and frequency of modifications (in Tolvanen, 1998, p. 59)

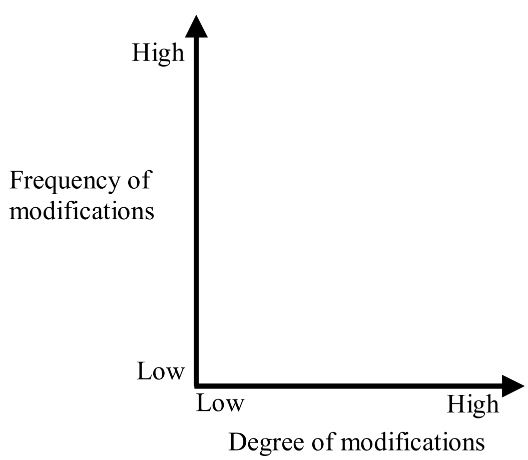


Table 1. Examples of local method development efforts (in Tolvanen, 1998).

Frequency of Modifications / Degree of Modifications	within a method	combine methods	own methods
continuous			Aalto 1993, Jaaksi 1997, Nissen et. al. 1996
project-by-project basis		Bennetts and Wood-Harper 1996	Tollow 1996
organisation contingency based		Kronlöf 1993, Kurki 1996, Cronholm and Goldkuhl 1994	
external method based	FIPS 1993a, CCTA 1995		

ISPI EVOLUTION MODEL

In this study the evolution of local ISPIs is studied by carrying out an analysis where the focus is on two dimensions of ISPI evolution, the degree of ISPI modifications and the frequency of ISPI modifications (see Figure 1, and Table 1). In our study three Finnish organisations were used as case examples over a 43-year time period (1954-1997). This investigation is crucial for ascertaining how the degree of ISPI modifications and frequency of ISPI modifications are varied.

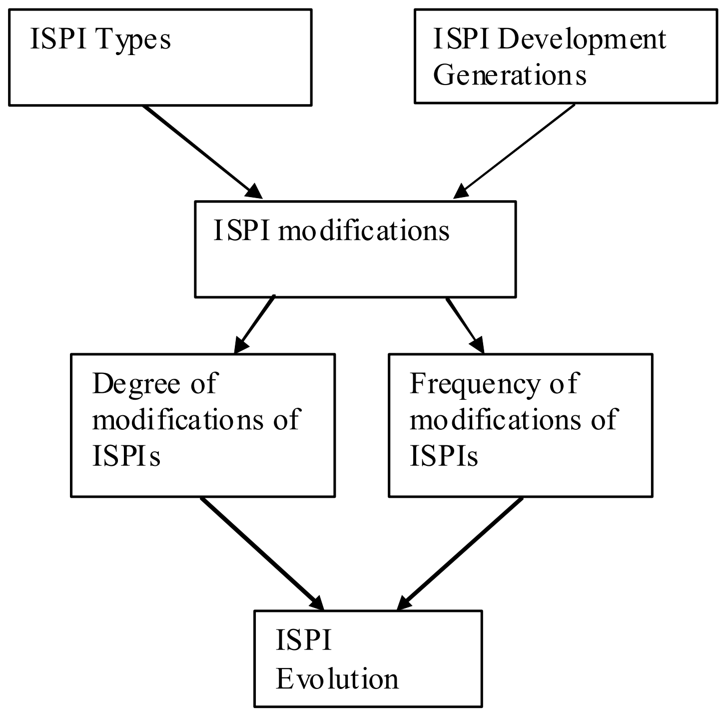
While past research does not help to analyse the variation between the ISPI modifications over time, Tolvanen's (1998) local method development framework (Figure 1) was adopted to draw attention to the ISPI modifications. Tolvanen (1998) classifies the degree of ISPI modifications into three categories, and the frequency of ISPI modifications into four categories (see Table 2). In the context of ISPIs based on past studies, and Tolvanen's (1998) local method development framework (see Figure 1) we derived our main research question as follows: "Why and how do ISPI modifications change over time across different ISPI categories and time generations in locales?"

Table 2. Degree of modifications and frequency of modifications in ISPI evolution

ISPI modification categories (Tolvanen, 1998)	Definition (Tolvanen, 1998)
Degree of ISPI modifications (Tolvanen, 1998): categories D1 to D3	The degree of modifications defines how large the changes are that are made to the local ISPI to improve its applicability (Harmsen et al., 1994a, 1994b)
D1: Tied to the selection paths provided by the ISPI (Harmsen et al., 1994a, 1994b)	Selection paths within a method. Here the only possible modification alternatives are those provided by the method (i.e. built-in flexibility), and thus are limited to a few contingency factors: development of small versus large systems, the use of prototyping, and the use of application packages.
D2: Based on combining ISPIs (Harmsen et al., 1994a, 1994b)	A combination of methods for internal use occurs when a chosen method, and its possible selection paths, does not meet the situational contingencies. The adaptation can be carried out either by combining available methods or method parts, or by modifying a single method for internal use.
D3: Based on the development of an organisation's own ISPI (Harmsen et al., 1994, 1994b)	An organisation or a project which develops its own methods faces situations which are outside the set of situations to which known methods are suited. Minor modifications into known methods are no longer sufficient.
Frequency of ISPI modifications (Tolvanen, 1998): categories F1 to F4.	How often an ISPI is changed (Hardy et al., 1995). More specifically, it measures how often changes in ISD situations are reflected in ISPIs.
F1: Advances and changes in external ISPIs (Tolvanen, 1998)	Method modifications based on advances in external method knowledge are typical in organisations where methods follow a national or industry standard. Thus, new versions are the result of externally decided modifications. Similarly, if the method is supported by a method-dependent CASE tool, the vendor can dictate the frequency of new versions.
F2: Changes in an organisation's ISD situations (Tolvanen, 1998)	Method modifications based on changes in an organisation's ISD situations deal with local method development in which contingencies related to the whole organisation change and are reflected in methods: outsourcing ISD, introducing new technologies, or starting to develop a new type of IS.
F3: A project-by-project basis (once an IS project starts) (Tolvanen, 1998)	Method modifications on a project-by-project basis are considered in method engineering (ME) research to be the most typical. Each project is characterised by individual features which need to be mapped to methods. Modifications are not made during the method use but only at the beginning of every project.
F4: Continuous refinement within a project (Tolvanen, 1998)	Continuous method refinement happens when ISD contingencies are uncertain or change rapidly, e.g. when a new method or methods are used in a new area. These modifications do not occur only at the individual level, but also in ISD projects, and in the longer run in the whole organisation.

In the context of ISPIs based on past studies, and Tolvanen's (1998) local method development framework (Figure 1), an ISPI evolution research model was developed (see Figure 2).

Figure. 2 An ISPI evolution research model.



FIELD STUDY ON ISPI EVOLUTION

A qualitative case study was chosen (Laudon, 1989; Johnson, 1975; Curtis et al., 1988) with a multi-site study approach, where three organisational environments were investigated, known here as companies A, B, and C, respectively. Company A is a big global paper-producer. Company B designs, implements, and maintains information systems mostly for company A but also for other companies in paper industry. The origin of company B is that in 1984 company A transferred its information systems (IS) department into a newly-formed company, company B that was owned partly by company A and partly by the employees of company B. In 1995 company B was further divided into five separate companies. One of them is company C which was located close to the headquarters of company B and continued to serve mainly company A. These three companies' development units have been situated in three separate Finnish cities. Company A was located in city in Eastern part of Finland and housed several IS activities between 1954-1969 in its separate functional departments (accounting, engineering etc.). In 1969 a separate IS department was established, and it was continued until 1984 when the department was transformed into a separate profit center. Company A had also in-house IS activities in Helsinki between the years 1961-1969. During 1969-1984 these belonged to the IS department of company A. Despite having separate locations, we chose to treat both sites as a development unit, named company A, due to the fact the two were working intimately together and belonged to the same IS department and also followed the same formal development guidelines. After the 1984 company B's site in the eastern part of Finland is treated as a separate development unit. Between the years 1995-1997, this site continued to operate separately. The third company -company C- was established in 1989 as a separate division which was located in a different city in Eastern Finland within company B. It continued its existence until 1995 under the formal management of company B. We treat it as a separate development unit because it had totally independent IS development functions. Operated on a different technological platform and it was treated as a separate profit center in company B. The IS and business knowledge within company A's IS department was inherited through outsourcing to company B. Not surprisingly, company B continued the same organisation structure as before the outsourcing, and company A recognised company B easily as its main IS vendor. Considerable organisational development and internal changes, as a result of ISPIs and market changes however, have taken place in fast pace since 1984.

Our study forms a descriptive case study (Yin, 1993): it embodies time, history and context, and it can be accordingly described as a longitudinal case study, which involves multiple time points (Pettigrew, 1985, 1989, 1990). The research approach followed was Friedman's and Cornford's (1989) study, which involved several generations and time points. This was because the bulk of the gathered data was qualitative, consisting of interviews and archival material, of which largely historical research methods were adopted (Copeland and McKenney, 1988; Mason et al., 1997a, 1997b).

Our definitions of ISPI modifications for development formed the basis for interviews and collection of archival material. Empirical data contained tape-recorded semi-structured interviews dealing with the experiences from developing and using ISPIs. The archival files and collected system handbooks, system documentation and minutes of the meetings were explored. The archival data encompassed a period between 1960 and 1997 serving as primary and secondary source of data (Järvenpää, 1991). Thus triangulation was used to verify the veracity of the data by using multiple data sources.

The first round of data was gathered between February 1995 and May 1997. The obtained data set was arranged in a manuscript, which included ISPI events etc. This manuscript was corrected for multiple mistakes and omissions. However since the analysis had several important omissions more data was gathered until November 1997, and a second version of the manuscript was written in December 1997. The new manuscript was again corrected for omissions and mistakes.

The data set was first arranged in the form of a Baseline Story Data manuscript that covered ISPI "events" etc. which were respectively arranged in chronological order. Using the validated data sets the events were arranged into a table were each development decision formed one row. Each row included a description of the company; the year when the development decision was made; its locale; the IS project; an incidence of the degree of ISPI modification; an incidence of the frequency of ISPI modification in each development decisions; and an incidence if the ISPI was internally developed. While "reconstructing" the historical evidence, we assumed that the modification was "influential" when it had supportive data. Thus, we found 124 development decisions where they were present. At the data categorisation stage, the degree of ISPI modifications and frequency of ISPI modifications were divided into four time generations, four ISPI categories, and three locales, which were company A, company B, or company C. Then the data set was converted into a data matrix based on the presence of a specific feature. For a single development decision, called a sample the maximum number of degree of ISPI modifications was three, and the maximum number of frequency of ISPI modifications was four. The data consisted of 16 binary variables; 3 variables for degree of modifications ("tied to the selection paths provided by a method" to "based on development of an organisation's own method"), 4 variables for frequency of ISPI modifications ("advances and changes in external methods" to "continuous refinement within a project"), 3 variables for the four time generations, 3 variables for the three locales, and 3 variables for the four ISPI categories. The presence of a feature was denoted by 1 and absence by 0 (like c.f. Ein-Dor and Segev, 1993). (ISPI category D and time generation one was left out from the analysis due to the lack of data).

From these 16 variables 7 were selected as independent variables which were used to explain the rest of the 9 dependent variables. The independent variables were (1) tied to the selection paths provided by the ISPI, (2) based on combining ISPIs, (3) based on development of an organisation's own ISPI, (4) advances and changes in external ISPIs, (5) changes in an organisation's ISD situation, (6) a project-by-project basis, and (7) continuous refinement within a project. The reason for this selection of the independent and dependent variables was based on our research question.

The variation in the ISPI modifications was modelled with the component plane and the U-matrix (unified distance matrix) representations of the Self-Organizing Map (SOM) (Kohonen, 1989; Ultsch and Siemon, 1990; Kohonen, 1995). The SOM is a vector quantisation method to map patterns from an input space VI onto typically lower dimensional space VM of the map such that the topological relationships between the inputs are preserved. This means that the inputs, which are close to each other in input space, tend to be represented by units (codebooks) close to each other on the map space which typically is a one or two dimensional discrete lattice of the codebooks. The codebooks consist of the weight vectors with the same dimensionality as the input vectors. The training of the SOM is based on unsupervised learning, meaning that the learning set does not contain any information about the desired output for the given input, instead the learning scheme try to capture emergent collective properties and regularities in the learning set. This makes the SOM especially suitable for our type of data where the main characteristics emerging from the data are of interest, and the topology-preserving tendency of the map allows easy visualisation and analysis of the data.

Training of the SOM can be either iterative or batch based. In the iterative approach a sample, input vector $x(n)$ at step n, from the input space V_I, is picked and compared against the weight vector w_i of codebook with index i in the map V_M. The best matching unit b (bmu) for the input pattern $x(n)$ is selected using some metric based criterion, such as ïï$x(n)$-$w_b$ïï = min_iïï $x(n)$-w_i ïï, where the parallel vertical bars denote the Euclidean vector norm. The weights of the best matching and the units in its topologic neighborhood are then updated towards $x(n)$ with rule $w_i\,(n+1) = w_i\,(n) + a(n)\,h_{i,b}(n)\,(x(n) – w_i(n))$, where i Î V_M and 0£$a(n)$ £1 is a scalar valued adaptation gain. The neighborhood function $h_{i,b}(n)$ gives the excitation of unit i when the best matching unit is b. A typical choice for $h_{i,b}(n)$ is a Gaussian function. In batch training the gradient is computed for the entire input set and the map is updated toward the estimated optimum for the set. Unlike with the iterative training scheme the map can reach an equilibrium state where all units are exactly at the centroids of their regions of activity (Kohonen, 1995). In practice batch training can be realised with a two step iteration process. First, each input sample is assigned best matching unit. Second, the weights are updated with w_i = å$_x\, h_{i,b(x)}\, x$ / å$_x\, h_{i,b(x)}$. When using batch training usually few iterations over the training set are sufficient for convergence. In our experiences we used batch learning scheme.

According to the experiences it is desirable to divide the training into two phases: 1) initial formation of a coarsely correct map, and 2) final convergence of the map. During the first phase the width of the function $h_{i,b(x)}$ should be large as well as the value of a should be high. The purpose of the first stage is to ensure that a map with no ``topological defects'' is formed. During learning these two parameters should gradually decrease allowing finer details to be expressed in the map. However, in most cases these choices are not so crucial, because the method tends to perform well for a wide range of parameter settings.

The mathematical properties of the SOM algorithm have been considered by several authors (e.g. Kohonen, 1989, 1995; Luttrell, 1989; Cottrel, 1998). Briefly, it has been shown that after learning the weight vectors in the map with no ``topological defects'' specify the centers of the clusters covering the input space and the point density function of these centers tends to approximate closely the probability density function of the input space. Such mapping, of course, is not necessarily unique.

The basic SOM based data analysis procedure typically involves training a 2-D SOM with the given data, and after training, various graphs are plotted and qualitatively or even quantitatively analysed by experts. The results naturally depend on the data, but in the cases, where there are clear similarities and regularities in the data, these can be observed by the formed pronounced clusters on the map. These observable clusters can provide clues to the experts on the dependencies and characteristics of the data, and some data clusters of particular interest can be picked for further more detailed analysis. To help this type of exploratory analysis, a typical visualisation step is so called component plane plotting (Kohonen, 1995), where the components of codebook vectors are drawn in the shape of the map lattice. By looking component planes of two or more codebook variables it is possible to observe the dependencies between the variables. The above type of component plane analysis was performed on the data analysed here.

The U-matrix (unified distance matrix) representation of the SOM (Ultsch and Siemon, 1990) visualises the distances between the neurons, i.e. codebooks. The distance between the adjacent neurons is calculated and presented with different colors. If a black to white colouring schema is used typically a white colour between the neurons corresponds to a large distance and thus a gap between the codebooks in the input space. A black colouring between the neurons signifies that the codebook vectors are close to each other in the input space. Dark areas can be thought of as clusters and light areas as cluster separators. In our case black and white coloured distances between codebooks are shown by colour bar in each U-matrix figure. This U-matrix representation can be a helpful when one tries to find clusters in the input data without having any prior information about the clusters. Of course, U-matrix does not provide definite answers about the clusters, but it gives clues what similarities (clusters) there may be in the data. Teaching SOM and representing it with the U-matrix offers a fast way to get insight on the data distribution. A simple algorithm for a U-matrix computation is as follows. For each node in the map, compute the average of the distances between its weight vector and those of its immediate neighbours. The average distance is a measure of a node's similarity between it and its neighbours.

The SOM map was trained with the data consisting of 124 samples, where each sample consisted of 7 independent variables (i.e., input space dimensionality is 7). After training, the dark units (the low values of the U-matrix) of the SOM represent the clusters, and light units (the high values of the U-matrix) represent the cluster borders.

RESEARCH FINDINGS AND ANALYSIS: ISPI MODIFICATIONS AND THEIR VARIATION OVER TIME ACROSS DIFFERENT ISPI CATEGORIES AND TIME GENERATIONS IN LOCALES

When searching for evidence on how organisations ISPI modifications vary it was discovered that the most important degree of ISPI modification observed was "based on the development of an organisation's own method (D3)" (68 %), and the second important degree of ISPI modification was "tied to the selection paths provided by a method (D1)" (21 %). The total number of occurrences of degree of ISPI modifications' was 171. The most important frequency of ISPI modification observed was "Changes in an organisations' ISD situations (F2)" (38 %), and "A project-by-project basis (once an ISD project starts) (F3)" (34 %). The total number of occurrences of frequency of ISPI modifications was 293 (see Table 3).

Table 3. ISPI modifications.					
Modification categories D1-D3, and F1-F4	Total number of occurrences in category D	Total number of occurrences in category T	Total number of occurrences in category TO	Total number of occurrences in category M	Relative amount in percentages
Degree of ISPI modifications categories					
Tied to the selection paths provided by a method (D1)	0	3	31	2	21 %
Based on combining methods (D2)	0	13	2	5	11 %
Based on the development of an organisation's own method (D3)	4	23	44	44	68 %
Total number of occurrences	4	39	77	51	100 %
Frequency of ISPI modifications categories					
Advances and changes in external methods (F1)	3	8	45	2	19 %
Changes in an organisations' ISD situations (F2)	3	18	45	44	38 %
A project-by-project basis (once an ISD project starts) (F3)	1	28	43	44	34 %
Continuous refinement within a project (F4)	0	22	0	3	8 %
Total number of occurrences	7	76	133	93	100 %
Total number of samples	11	115	210	144	100 %

Then next investigation of how the 124 samples in the data matrix were distributed according to three locales, four ISPI categories, and four time generations was carried out (see Table 4, Table 5, and Table 6).

Table 4. Sample distribution in the three locales.

Locale	Number of samples in category D	Number of samples in category T	Number of samples in category TO	Number of samples in category M	Relative amount %
Locale one (company A)	2	14	15	44	66
Locale two (company B)	0	4	30	2	29
Locale three (company C)	2	9	0	0	5

Table 5. Sample distribution in the four ISPI categories.

ISPI Category	Number of samples	Relative amount %
M (Project management and control procedures)	144	30
T (Technology)	115	21
TO (Development tools)	210	47
D (Description techniques)	11	2

Table 6. Sample distribution in the four time generations.

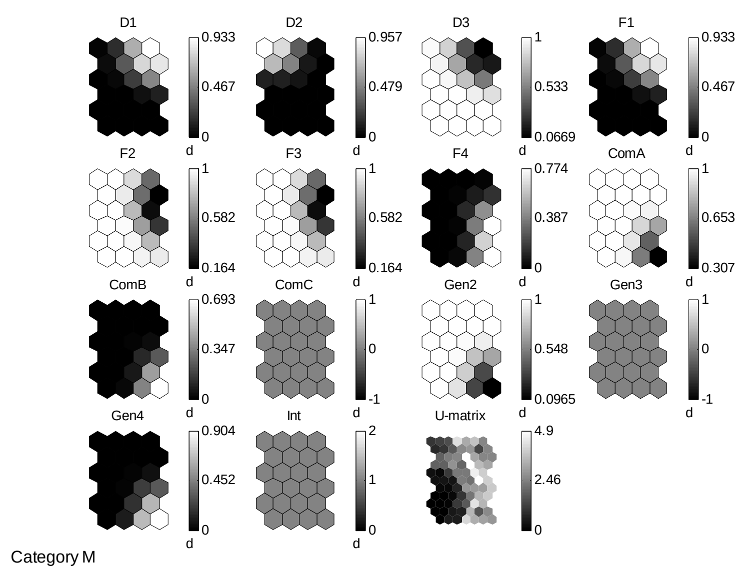
Time generation	Number of samples in category D	Number of samples in category T	Number of samples in category TO	Number of samples in category M	Time frame	Relative amount %
One	0	0	0	0	1954-1965	no samples
Two	2	14	16	43	1965-1984	61
Three	0	2	5	0	1984-1990	7
Four	2	11	24	3	1990-1997	32
Total number of samples	4	27	45	46		100 %

Locale three (company C) has the minority of the samples, and its time generation is the shortest. Locale one (company A) and locale two (company B) are different having a different number of samples and also their time generations are different. Time generation one has no samples, and therefore it is left out from the analysis. ISPI category D (description techniques) has only 2 % of the samples and therefore it is left out from the analysis. While locale one (company A) exists both in time generations one and two, time generation two becomes the most import lasting for 20 years.

The U-matrix visualises the distances between neighbouring map units, and helps to see the cluster structure of the map. The high values of the U-matrix (light units) indicate a cluster border. The elements of the same clusters are indicated by uniform areas of low values (dark units) and thus similar data is grouped together. The colour bar indicates the colour and its meaning. Figure 3 below presents the component planes and the U-matrix in a SOM of 4x6 units of variables in ISPI category M (project management and control procedures) and employing the seven independent variables: D1 (tied to the selection paths provided by the ISPI), D2 (based on combining ISPIs), D3 (based on the development of an organisation's own ISPI), F1 (advances and changes in external ISPIs), F2 (changes in an organisation's own ISPI), F3 (a project-by-project basis), and F4 (continuous refinement within a project); and the six dependent variables: ComA (Company A), ComB (Company B), ComC (Company C), time generation two (Gen2), time generation three (Gen3), and time generation four (Gen4).

Figure 4 presents the component planes and the U-matrix in 4x6 units of variables in ISPI category T (base line technology innovations). Figure 5 presents the component planes and the U-matrix in 4x6 units of variables in ISPI category TO (development tools). Notice, that the middle grey colour in a component plane variable, such as in "Int", is a constant being 1 or 0, as its value is in the learning set.

Figure 3. The component planes and the U-matrix in a SOM of 4x6 units of variables D1, D2,D3, F1, F2, F3, F4, ComA, ComB, ComC, Gen2, Gen3, and Gen4 in ISPI category M.

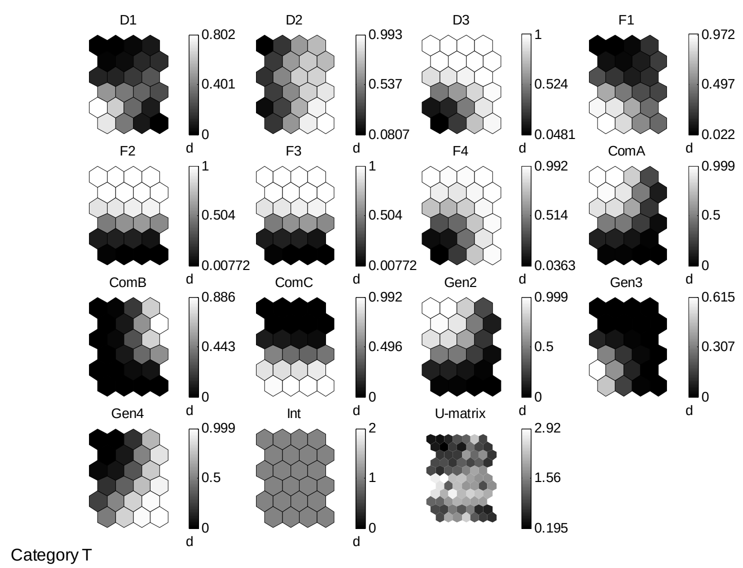


The component planes (the variables D1 to Int), and the U-matrix were investigated, and the following was discovered (Figure 3): Two clearly seen clusters are present in this dataset. The first cluster is situated in the upper left corner of the U-matrix and the second cluster is situated in the lower left corner of the U-matrix for ISPI category M.

In the first cluster (the upper left corner cluster), high values existed in the variables D2, D3, F2, F3, ComA, and Gen2, and the second cluster (the lower left corner cluster), high values existed in the variables D3, F2, F3, ComA, and Gen2.

Only company A in the second time generation (Gen2) used ISPI modifications D2 (based on combining ISPIs), D3 (based on the development of an organisation's own ISPI), F2 (changes in an organisation's ISD situations), F3 (a project-by-project basis once an IS project starts). The other companies B and C did not use any modifications in the ISPI category M.

Figure 4. Component planes and U-matrix in a SOM of 4x6 units of variables D1, D2, D3, F1, F2, F3, F4, ComA, ComB, ComC, Gen2, Gen3, and Gen4 in ISPI category T.



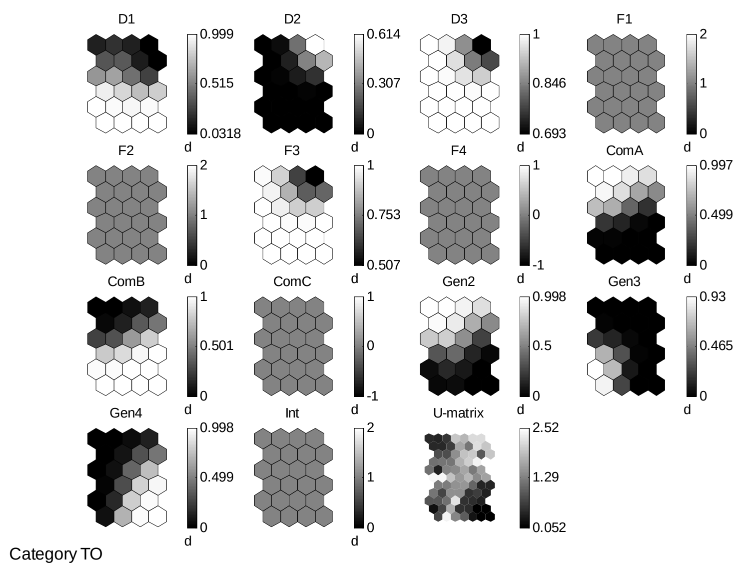
The component planes (the variables D1 to Int), and the U-matrix were investigated, and the following was discovered (Figure 4) in ISPI category T: Two clusters are clearly present in this dataset. The first cluster is in the upper part of the U-matrix, and the second cluster is the lower part of the U-matrix. Between these two clusters there is the cluster border (lighter units).

In the first cluster (the upper part of the U-matrix), high values existed in the variables D2, D3, F2, F3, F4, ComA, and Gen2. In the second cluster (the lower part of the U-matrix), high values existed in the variables D1, D2, D3, F1, F4, ComC and Gen4.

Company A in the second time generation (Gen2) used ISPI modifications D2 (based on combining ISPIs), D3 (based on the development of an organisation's own ISPI), F2 (changes in an organisation's ISD situations), F3 (a project-by-project basis once an IS project starts), and F4 (continuous refinement within a project).

Company C in the time generation four (Gen4) used D1 (tied to the selection paths provided by the ISPI), D2 (based on combining ISPIs), D3 (based on the development of an organisation's own ISPI), F1 (advances and changes in external ISPIs), and F4 (continuous refinement within a project).

Figure 5. Component planes and U-matrix in a SOM of 4x6 units of variables D1, D2, D3, F1, F2, F3, F4, ComA, ComB, ComC, Gen2, Gen3, and Gen4 in ISPI category TO.



The component planes (the variables D1 to Int), and the U-matrix were investigated, and the following was discovered (Figure 5) in ISPI category TO: Two clusters are clearly present in this dataset. The first cluster is in the upper left part of the U-matrix, and the second cluster is in the lower part of the U-matrix. Between these two clusters there is the cluster border.

In the first cluster (the upper part of the U-matrix), high values existed in the variables D2, D3, F3, ComA, and Gen2, and the second cluster (the down part of the U-matrix), high values existed in the variables D1, D3, F3, ComB, Gen3, and Gen4.

Company A in the second time generation (Gen2) used ISPI modifications D2 (based on combining ISPIs), D3 (based on the development of an organisation's own ISPI), and F3 (a project-by-project basis once an IS project starts).

Company B in the third time generation (Gen3) and four (Gen4) used D1 (tied to the selection paths provided by the ISPI), D3 (based on the development of an organisation's own ISPI), and F3 (a project-by-project basis once an IS project starts).

DISCUSSION AND CONCLUSIONS

Based on found clusters in the Figures 3, 4, and 5 it was found the following issues. Companies B and C in the project management and control procedures category ISPIs did not make any modifications. On the other hand company A in time generation two made modifications to project management and control procedures category ISPIs. Time generation two can be characterised as a poor productivity of the system developers and difficulties of delivering reliable systems on time and within the budget. The modifications were based on combining ISPIs, based on the development of an organisation's own ISPI, changes in an organisation's ISD situations, and on a project-by-project basis.

The reasons for these modifications are as follows. The rules and administrative procedures that help control, manage and co-ordinate ISD activities were always project based. The project management and control procedures category ISPIs were adapted for each project's use. The situations and the environment in which the projects took place were different from each other. The IS project groups developed their own IS project management and control procedures to meet the changing situations in technology, in resources, the project timetables, and the environment. Company A's (locale one) ISD situations changed because the organisation structures were changed and the IS organisation was changed. Outsourcing occurred in 1984 and the IS department was sold out, but the lack of resources (money, time, people) began already in the end of the 1970's, and finally it ended in the outsourcing decision. New technologies came on the market and new types of information systems were developed already in the 1970's, such as the order handling IS for the whole of company A. The project management and control procedures category ISPIs were taken in to use of the beginning of the IS projects and used until the end of the project.

Company A in time generation two made modifications to technology innovations category, which consisted of externally developed technical platforms, like programming languages, database management systems, and middleware components. Time generation two can be described as time of software constraints. The modifications were based on combining ISPIs, based on the development of an organisation's own ISPI, changes in an organisation's ISD situations, a project-by-project basis, and continuous refinement within a project.

Company C in time generation four made modifications to technology innovations category. Time generation four can be described as complex interactions between the systems and the actors, in other words as organisational constraints. The modifications were based on tied to the selection paths provided by the ISPI, based on combining ISPIs, based on the development of an organisation's own ISPI, advances and changes in external ISPIs, and continuous refinement within a project.

Both companies A in time generation two and company C in time generation four used the following modifications: based on combining ISPIs, based on the development of an organisation's own ISPI, and continuous refinement in a project. On the other hand the companies A and C had two differences in modifications: tied to the selection paths provided by the ISPI, and advances and changes in external ISPIs (only time generation two was included). The modification tied to the selection paths provided by the ISPI can be explained with the prototyping and application generators which came on market and were used in information system development. Advances and changes in external ISPIs can be explained by the fact that case tools were taken in to use, external technology platforms were changing: UNIX, windows, object orientation, C language, C++ language etc. were taken in to use.

The development tools category includes productivity tools for system development covering application generators, case tools, documentation tools, data dictionaries, or tools to configure, or manage software components. Time generation two can be described as software constraints, time generation three as user relationships constraints, and time generation four as organisational constraints. Information system development was uncertain and changes occurred rapidly. The whole organisation was changing, and the modifications occurred in the whole organisation. ISD situations changed and even internal ISPIs were modified for internal use. The IS project group developed its own technology category ISPIs. Technology was changing and it affected on the ISD.

Company A in time generation two, and company B in time generation three and four made the similar modifications: tied to the selection paths provided by the ISPI, based on the development of an organisation's own ISPI, and on project-by-project basis modification. Modifications tied to the selection paths provided by the ISPI can be explained by the fact that the development of small versus large systems, the use of prototyping, or use of application packages, such as internally developed Carelia tools. Based on the development of an organisation's own ISPI modification can be explained by the fact that the situations in ISD are changing and ISPIs must be changed. Large modifications are needed. Project-by-project basis modification can be explained by the fact that every IS project makes modifications.

The difference between the companies A and B was that company A in time generation two also used combining ISPIs, because the situational contingencies were not met, and adaptation was needed. Combining a single method, or method parts, or modifying a single method for internal use was important. This combining of ISPIs was the only difference between company A and company

B. Company C in time generation four had no data in development tools category. Table 7 summarises the modifications in the three organisations over time.

Table 7. The modifications in the ISPI categories in three locales over time				
Locale	Time generation	Project management and control procedures category	Technology innovations category	Development tools category
Company A (locale one)	Gen 2	Combining of ISPIs, based on the development of an organisation's own ISPI, changes in an organisation's ISD situations, project-by-project basis modification	Combining of ISPIs, based on the development of an organisation's own ISPI, changes in an organisation's ISD situations, project-by-project basis modification, continuous refinement in a project	Modifications tied to the selection paths provided by the ISPI, combining of ISPIs, based on the development of an organisation's own ISPI, project-by-project basis modification
Company B (locale two)	Gen 3	-	-	Modifications tied to the selection paths provided by the ISPI, based on the development of an organisation's own ISPI, project-by-project basis modification
Company B (locale two)	Gen 4	-	-	Modifications tied to the selection paths provided by the ISPI, based on the development of an organisation's own ISPI, project-by-project basis modification
Company C (locale three)	Gen 4	-	Modifications tied to the selection paths provided by the ISPI, combining of ISPIs, based on the development of an organisation's own ISPI, advances and changes in external ISPIs, continuous refinement in a project	-

The analysis reported here shows that in the organisations the ISPI modifications varied significantly according to the ISPI category, and the time generation. The variation in modifications can partly be explained by differences in the development environments, differences in ISPI categories, and difference in the organisations.

Major findings from our field study over time indicated that before the internal IS department outsourcing in 1984 modifications were carried out in technology innovations, development tools, and project management and control procedures category ISPIs. After outsourcing no modifications were made in project management and control procedures ISPIs, and companies B and C began to concentrate on development tools, and technology innovations respectively. Therefore when comparing the modifications in company A and B in development tools category ISPIs the findings indicated that they made almost the same kind of modifications. On the other hand, in technology innovations ISPI category company A and company B used both similar and different modifications.

Our findings indicate clearly that ISPI modifications occur in a deterministic fashion in the organisations. The three organisations spent and great effort, time, and resources to modify the ISPIs to be suitable to ISD. These modifications were necessary to meet the changing IS development environments. In the organisations the decision making to change the ISPIs was rational, and the goal was to develop the IS projects. It was also an economical decision to achieve the customers' needs in the IS projects in certain time and money. ISPI modifications or customisations were made in order to meet the needs of the IS projects. Also the organisations, the locales had their own needs in IS projects to be full filled.

IMPLICATIONS FOR RESEARCH AND METHODOLOGY

Empirical research on how and why ISPIs are modified is lacking. ISPI evolution literature is very rare. This longitudinal data is important, because a horizontal survey research would not have given answers to our research question how and why ISPI modifications were changed over time. One of the most important requirements to study ISPI evolution phenomena in other organisations is that their ISPI evolution, use of ISPIs is based on the Friedman and Cornford's (1989) categorisation of the four time generations.

Swanson (1994) presented three types of innovations in his model whereas in this study his first type innovations (administrative and technological, Ia and Ib) are used for IS task. We further expanded both the Ia and Ib type innovations into two subcategories. In the administrative ISPI category we distinguished between management innovations and description innovation. Within technology innovations, we separated between tool innovations, and core technology innovations. Introducing these innovations into ISPI evolution research is important if we want to integrate empirical ISPI research with design and development of IS research.

We discovered a relationship between degree of modifications of ISPIs and frequency of modifications of ISPIs. The relationship can be seen visually from the Figures 3, 4, and 5 even if we did not measure a correlation or a linear relationship between the modifications. An important implication to methodology is the use of multi method research approach. In this study triangulation (Yin, 1993) was used to increase the reliability of the data. Even if our case study has weaknesses, we produced a logical chain of evidence with multiple data points. Using U-matrix representation as the analysing tools was proved to be suitable to the data analysis, even if there is no study were such a method is previously applied.

IMPLICATIONS FOR PRACTITIONERS

In our study the organisations faced situations were the ISD project groups modified and integrated the ISPIs together in order to manage and control the ISD. The users of the ISPIs become innovators. By the ISPI modifications the organisations enhanced the productivity of an ISPI by increasing its efficiency and effectiveness. ISD practices changed in these organisations, and the ISPIs induced disruptive innovations into ISD processes as they changed the nature of the problems and design spaces they imposed. The studied organisations were forced to invent and modify their own ISPIs suitable for technological platforms for the IS client. The organisations were aggressive and innovative towards modification of the new technologies and they have regarded themselves as the first class technological users, and this innovative tendency continued after the outsourcing. Thus, our findings indicated that IT leaders need to plan IS projects, of course, but that they also need to be flexible. This longitudinal study found that IT leaders work with plans that need to be modified as the plans unfold. If the leaders that we discovered had been unwilling to modify their plans then we believe that the several IS projects would have failed. The IT leaders, however, modified their plans in the companies A, B, and C with the following benefits, such as ISD work succeeded and information systems were delivered on time. It can be said that the plans are important but they must be flexible.

LIMITATIONS AND FUTURE RESEARCH

There are some limitations in our study. First the classification of ISPI data into innovation categories had to be accomplished sometimes by using the limited knowledge of the context and content of the innovation because access to secondary sources was allowed alone. The second limitation was concerned with the limited number of studied companies. The third limitation was concerned with the findings, which can be generalised across a set of organisations with care. At the same time, they showed that generalising explanations for variations in ISPI activities was difficult, and should be made with considerable caution. The fourth limitation was concerned with the results which may not be readily applicable to other organisations since the phenomena in this study was atypical. Thus, generalisation of the results was difficult, but not necessary impossible. If it were possible to collect the same kind of data from other organisations, the analysing methods used in this thesis would be applicable. The fifth limitation was concerned with the research model (Figure 2) suggesting a large number of modifications, which are not easy to observe with the recall method followed, the historical research method is limited, and our division into ISPI categories had to be made roughly, and interpretations are heuristic.

In the future a further subject of study could be the task of describing the ISPI modification process. Furthermore, the modifications' control groups, such as IS project groups, the customers, the users etc. could be also an interesting subject of study. One particular interesting subject of study would be to study the antecedents, and consequences of the ISPI modifications.

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