Enhancing transformational and incremental innovation with ICT

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Abstract

The ever-more turbulent business environment of agro-food industries requires fast and effective innovation of varied dimensions of products and business processes. In realizing this, innovation processes should be organized smoothly. This implies that both incremental improvements and transformational innovations processes are integrated and embedded deeply in the entire organisation. Information and Communication Technology (ICT) can have an important enhancing role by providing valuable tools to capture, structure and communicate the required information and thus making complexity manageable for human mind. In the paper this enhancing role is elaborated in a conceptual innovation framework and the required ICT-architecture is illustrated by a case study in Dutch arable farming.

Key words: Innovation, Information and Communication Technology, Change Management, Information Architecture, Arable Farming

1 Introduction

The business environment in the agro-food industries is changing rapidly. A vital factor to survive, or better to succeed in this turbulent environment, is the ability to innovate. Organizations should continuously be able to deliver products that at least meet the variable and varied consumer needs in a competitive and sustainable way. This requires innovation of product-market proposition (e.g. by developing new products or services, improving existing products, choosing new markets and distribution channels) and innovation of business processes, which enables the production and distribution of new products or reduces the cost of existing products. Although innovation is primary about people, Information and Communication Technology (ICT) can have an important impact on the quality of innovations and the speed at which they can be realized. In this paper this enhancing role is elaborated in a conceptual innovation framework and the required ICT-architecture is illustrated by a case study in Dutch arable farming.

2 Conceptual innovation framework

How can ICT support innovations? In order to answer this question it should be clear what innovation is about and how innovation processes look like. In this section a conceptual framework is proposed, focussing on the objectives, object and process of innovation.

2.1 The innovation objectives: why to innovate?

The rationale of companies is to deliver added value to customers within social, legal and environmental constraints. The added value is realized by fulfilling varied customer needs better, faster and cheaper than

competitors with distinctive products (goods and services) as a result of effective and efficient execution of business processes. Key characteristic of today's business environment is the volatility of markets in terms of growing demand variability, intensification of competition and fast technical, economic, social/legal and environmental developments. Innovation is of vital importance to sustain delivering added value in this changing environment. Objectives are to assure and improve business performance (quality, lead time, costs, et cetera) continuously and thus to survive and succeed for the long term.

2.2 The innovation object: what to innovate?

The object of innovation processes has many dimensions. First, a distinction should be made between product and process innovation (among others Grunert et al. 1995):

- *Product innovation* is related to the output of production systems: new goods and services, including its inherited attributes and its market proposition.
- *Process innovation* is broadly defined as innovation of the complete system that generates the required products. It involves all elements of these systems including technical and natural resources, and human capital. Processes of the involved enterprises are the core of this system. Processes are structured and measured sets of business activities designed to produce a specific output of value for a particular customer or market (Davenport 1993; Van der Vorst et al. 2005). Activities are performed by cooperating people with the help of technical resources perform.

One can distinguish between three types of business processes (In 't Veld 2002):

- *Primary processes* contribute directly to the creation of products and thus to the adding of value in the market place. Examples are design, sourcing, production, sales, distribution and development.
- *Supporting processes* take care for the development, deployment and maintenance of resources that are required in primary processes. In this way they contribute indirectly to the value adding process. Examples are Human Resource Management, development, deployment and maintenance of the machine park, Facility Management, Financial Administration and IT Service Management.
- *Management processes* are aimed at assuring and improving the effectiveness and efficiency of the business processes and the alignment of business processes with the environment.

There are several dimensions of management processes:

- *Physical production control* (mechanization): management that is directly related to the physical infrastructure of the product and means of production, on basis of technical measurements (sensoring and scanning) the production process is adjusted automatically;
- *Enterprise management*: planning and control of business processes on several levels of detail and different time horizons, including management on executive and business unit level on basis of a balanced set of performance indicators, master production planning on basis of actual or forecasted customer orders, operational planning of material and resource needs and continuous work order management by assigning and adjusting specific work instructions;
- *Chain management*: the alignment of enterprise management with other involved chain actors, this is also possible on the distinguished levels of detail and time horizons.

Process innovation can be related to all these interdependent process dimensions. It may improve business performance for example by changing the activity structure of primary, secondary and management processes, as well as by developing the competences of involved individuals, the required formal and informal cooperation between people, and the usage of technical and natural resources.

2.3. The innovation process: how to innovate?

The ever-more turbulent environment requires fast and effective innovations of all related dimensions of the innovation object. This is not easy to realize. It requires seamless streamlining of innovation processes and embedding it deeply into the organisation's competences. There are different approaches of organizing business innovation processes.

With the emerging of quality thinking the importance of continuous improvement in small steps was stressed: incremental innovation. According to the Total Quality Management movement this evolutional innovation should be embedded deeply in the entire organisation (including individual attitude and competences, organisational structure and systems, culture and management style). In reaction, the

Business Process Redesign (BPR) movement argued that incremental innovation is not sufficient to realize break-through changes. BPR emphasizes radical and fundamental redesign of business processes. This revolutionary approach implies a total new start in which the current situation is departed completely. Business processes are set up again from scratch and the possibilities of information technology are used intensively. According to Hammer & Champy (Hammer and Champy 2001), the founders of the BPR-approach, only in this way drastic improvements of the business performance can be realized. However, in practice many BPR projects failed. An important cause was the ambition to make a complete new start independently from the current situation. This results in high resistance to change and loosing control, also due to the broad scope and neglecting of valuable existing knowledge and competences. BPR was presented as alternative of TQM. However, several authors (Macdonald 1995; Yeo 1996; Pereira and Aspinwall 1997) showed that a TQM approach increases the success of revolutionary changes by strengthening innovativeness and the ability to change. In other words, TQM and BPR are complementary approaches that reinforce each other.

Thus two major innovation approaches can be distinguished: incremental and transformational innovation. Incremental innovation is an evolutionary approach of continuous evolutional improvements in small steps. Improvements take place within the existing dynamic equilibrium (steady-state) and involve some extent of control. Transformational innovation is a revolutionary approach of periodic radical and fundamental changes in order to realize drastic improvements. It implies coming loose of current situation and moving towards a new equilibrium (from one steady-ate to another). Transformational innovations are characterized by a certain degree of chaos, which may be temporary at the expense of the productivity. Incremental and transformational innovation processes are complementary and reinforce each other. Both should be embedded and integrated in the entire organisation. This implies that innovation processes should be integral parts of organisational management processes. In order to realize this in next session the incremental and transformational innovation processes are elaborated in two connected and interacting innovation cycles.

2.4 Interacting cycles: how to embed innovation?

Continuous improvement by incremental innovation is a central concept of quality management movement. The Deming circle plays an important role (Deming 1982). According to this circle continuous improvement is an iterative process of setting objectives (plan), assuring process execution (do), measuring process execution (check) and if necessary implementing improvements (act). Based on the Deming circle, the following phases of *incremental* innovation can be distinguished:

1. *Plan*: the development of Specific, Measurable, Achievable, Relevant and Time Based (SMART) objectives and elaboration of the planning to realize these objectives;
2. *Execute*: execution of primary and supporting processes in order to realize the objectives and planning, including assurance of required process execution by triggering the right activities and guiding the appropriate usage of resources and material (instructions);
3. *Monitor*: measurement and registration of process performance and alerting in case of departures from the objectives;
4. *Evaluate*: evaluation of monitoring alert information and the initiation of corrective or preventive actions if necessary.

Transformational innovation is also an iterative and dynamic process. Key differences with the incremental innovation cycle are the nature, scope, depth and frequency of the innovation process. Besides the BPR school of thinking, transformational innovation processes are studied from several other perspectives. The most important are:

- Change management: theory building about the planned implementation of complex organizational changes. A dominating concept in change literature is the unfreezing-moving-refreezing model of Kurt Lewin (Lewin 1947). He argued that the existing organisational behaviour is the result of balance of restraining and driving forces (equilibrium). A planned change process starts with *unfreezing* the current organisation by setting up the existing balance. In this stage the old routines and traditions are pulled down and visualizing the gap between the desired and current behaviour creates awareness of the need for change. Next the organisation can *move* from the old to the new state by changing attitude and behaviour. A change process ends in *refreezing* the new state. This stage includes acceptation and stabilisation of the new behaviour, and assurance of continuous improvement to avoid falling back to the old routines.

- Innovation management: traditionally this theory stream has a strong focus on adoption and diffusion of product innovations. An authoritative model is the innovation-decision process of Rogers (Rogers 1995). This conceptualization consists of five stages: *knowledge* (becoming familiar with the innovation), *persuasion* (forming of a favourable or unfavourable attitude towards the innovation), *decision* (choosing to adopt or reject the innovation), *implementation* (putting the innovation in use) and *confirmation* (reinforcement of a innovation-decision already made or reversing a previous decision). However, the focus in innovation research has gradually evolved towards the entire process of developing new items (Omta 2004), resulting in more emphasis on organisational and managerial issues.
- Decision making: theory building about the process of making decisions. Well-known is the phasing of Simon (Simon 1977). In his view a decision-making or problem solving process consists of the phases: *intelligence* (defining and specifying the problem, objectives and solution method), *design* (inventing, developing and analyzing possible courses or pathways to solve the problem) and *choice* (choosing the best alternative).
- Management control: theory building about how organizations are managed. Classical is the distinction between the three types of control (Anthony 2003): *strategic planning* (process of deciding on the goals of the organization and the strategies for attaining these goals), *tactical management control* (the process by which managers influence other members of the organization to implement the organisation's strategies) and *operational control* (the process of assuring that specified tasks are carried out effectively and efficiently). Strategic and tactical management are part of the transformational cycle, while operational control is part of the incremental cycle.
- Strategy: this theory stream focuses on positioning companies in its environment to create a competitive advantage in delivering added value to customers. There are many different strategic schools (Mintzberg et al. 1998). The classical rational analytical approach of strategic planning focuses on the following phases of strategy development (Hellriegel and Slocum 1993): develop mission and objectives, diagnose threats and opportunities, assess strengths and weaknesses, generate alternative strategies, develop strategic plan, develop tactical plans, control and assess results and repeat the planning process. The emphasis is shifting towards the dynamics of the strategic process.

Based on a synthesis of these perspectives (focused on the role of ICT), the following phases of *transformational* innovation can be distinguished:

1. *Discover*: observation, creating (problem) awareness, idea generation and analysis of innovation opportunities based on information of the environment and internal reflection;
2. *Design*: elaboration, investigation and development of useful solution alternatives and the related modelling in interaction with organisational members and other stakeholders;
3. *Decide*: weighing alternatives and choosing the best alternative;
4. *Implement*: implementation of the chosen alternative, assuring and optimization the new situation by embedding it in the incremental innovation cycle;
5. *Reflect*: evaluation of the transformational process, determine new problems and innovation opportunities and initiating the discovering stage.

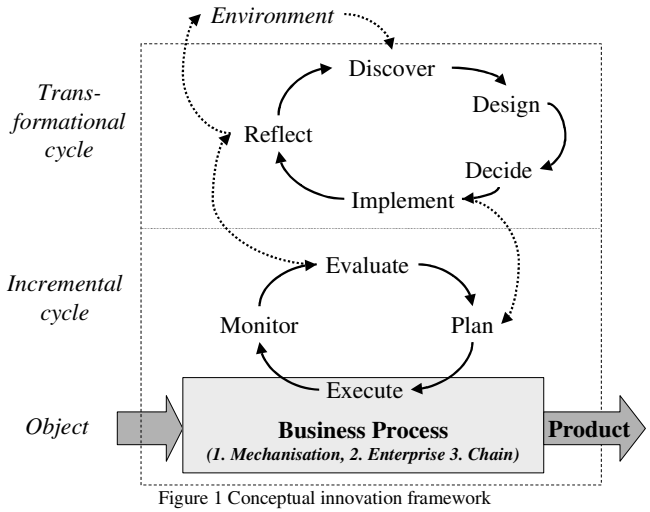

Figure 1 Conceptual innovation framework

Successful innovation is realized if both innovation wheels are rolling seamless and accelerating each other. The incremental and transformational innovation processes are integrated in the conceptual model as visualized in Figure 1. A transformational innovation process starts with the discovery of new innovation possibilities on basis of external observations (of opportunities or threats) or internal reflection. After the design of the alternatives and decision-making, the chosen alternative is implemented, which means that the transformational change is embedded in the operational incremental innovation cycle. This implies that the planning and objectives are adjusted to the renewed situation, the renewed processes are executed, measured and controlled after which the performance is evaluated and continuously improved. New operational performance evaluations are the basis of the reflection on the transformational change process. The reflection may result in starting up new transformational innovations of actions are performed to influence the environment in the desired direction, as far as that is within the sphere of management's influence.

3. Role of ICT

Information and Communication Technology (ICT) can have an important impact on the quality of innovations. The role is twofold.

On the one hand, it is an important dimension of the *innovation object*. New ICT techniques give new opportunities for both product and process innovation. Information is part of the product and is of increasing importance in consumer communication. An example in food is adding traceability information that can be viewed by consumer via Internet or scanners in the supermarket. Also in process innovation, ICT is nowadays of vital importance. Information is crucial to enable the execution and management of business processes. New ICT techniques result in new opportunities for process improvement. Examples are logistical optimization by integrated enterprise systems or RFID, optimizing of the growing process by advanced sensor techniques and technical decision support systems, alignment of chain processes by data exchange (EDI, XML) and integrated Chain Information Systems.

On the other hand, ICT can have an important impact on the quality of the *innovation process* itself. ICT supports both the incremental and transformational innovation processes. All activities of the incremental and transformational innovation cycle are information processing activities. They require information about environmental developments, innovation alternatives, decided solutions, implementation possibilities, objectives, plans, orders, instructions, procedures, performance, evaluations, et cetera. Information and communication technology (ICT) provides valuable tools to capture, structure and communicate these complex and dynamic information-processing activities.

In the incremental innovation cycle the focus of ICT support is on the information infrastructure of operational planning and control. The support in the different phases can be as follows:

1. *Plan*: performance indicator and planning functionality among others in Executive Support Systems (ESS), Management Information Systems (MIS), planning modules of Enterprise Resource Planning (ERP) systems (including Sales Planning, Master Production Planning, Material Requirements Planning, et cetera), Advanced Planning Systems (APS) to support and optimize specific planning algorithms (often used in combination with ERP-systems) and integrated chain planning systems (Collaborative Planning, Forecasting and Planning, CPFR).
2. *Execute*: workflow support and registration of product and process performance information, including scanning, sensoring and identification (barcoding, RFID) techniques. Important element is the transaction processing functionality of Enterprise Systems (integrated into one total ERP-system or software for specific business functions like Manufacturing Systems, Warehouse Management Systems, Customer Relations Management applications, Financial Management software) and Chain Information Systems. These systems heavily rely on registration of data in distributed or central databases.
3. *Monitor*: the automated determination of process performance and alerting in case of departures from objectives, amongst others in Supervisory Control And Data Acquisition (SCADA) and early warning systems. These systems measure process conditions continuously and alert if there is a performance regression or serious risk, based on an intelligent reaction on condition changes (e.g. with the help of data mining techniques).
4. *Evaluate*: the analysis of the monitoring information and automatic generation of improvement advices, including Business Intelligence (BI) software to transform basic data into useful

management information, e.g. in the form of management cockpits or dashboards. BI systems are mostly based on data warehouses.

In the transformational innovation cycle the focus of ICT support is on making complexity manageable for the human mind. The support in the different phases can be as follows:

1. *Discover*: stimulation of awareness by interactive and tailored alerting, visualisation and structuring of information about external opportunities and threats and internal strengths and weaknesses among others by means of diagnosis, gaming and creativity tools, including computer-aided brainstorming;
2. *Design*: supporting the systematic elaboration and modelling of the solution alternatives, e.g. by means of process modelling tools and product design software;
3. *Decide*: weighing designed alternatives against each other and advice about the best solution, supported by optimization models to find the optimal design parameters given the objective and simulation models to calculate the performance of different process scenario's dynamically. These models are often directly linked to the design process;
4. *Implement*: supporting the implementation of the chosen design and embedding it in operational management and control, including the information infrastructure. Important enabling factors are smart re-usage of model and application components (templates, reference model approach) and dynamic generation of the operational information infrastructure based on the elaborated design. This is facilitated by a Model Driven Architecture (MDA) approach in which software design (architecture) is isolated from programming code and formalized in several consistent model levels that can be interpreted by computers. Besides, ICT can support the implementation process e.g. by means of project management tools;
5. *Reflect*: tools to determine opportunities and problems from evaluation information e.g. by means of data mining techniques, advanced visualisation techniques and benchmarking.

Using ICT in the distinguished phases of incremental and transformational innovation is not enough for success. Making innovation really work requires seamless and timely alignment of different incremental and transformational innovation processes. To support this effectively an integrated usage of ICT tools is needed. This can be realized by an integral architecture as is illustrated in next session.

4. Knowledge in the field of arable farming – case study on an enabling ICT architecture

In 2004, a preliminary study was conducted for a new programme 'Knowledge in the field of arable farming', abbreviated from the Dutch acronym as KodA, for the period 2005-2008 (Wolfert et al. 2005). The central question it contained was: how can farming practice on arable farms be brought up to a higher level (market-orientation, quality, sustainability) through optimal passing-on of existing knowledge and the best use of existing data with the help of integrated management-support systems? Two main conclusions were that 1) the development of management support systems must be aimed at a synthesis between available research and other knowledge and up-to-date information and data from the crop, farm or chain and 2) the systems to be developed must be embedded in a broader, flexible farm framework and open ICT infrastructure, with the process being expressly driven by farming practice (the users).

Using the conceptual framework of transformational and incremental innovation, the existing knowledge and possibilities in the area of management support on arable farms were mapped through an extensive desk study (Achten et al. 2005). The focus in available tools appeared to be on operational planning, execution and monitoring systems. On the other hand many models exist for design and decision support. Technical oriented and arable specific tools are dominating. More behavioural and managerial tools for discovery, implementation and reflection are rare, but evolving. It emerged from the analysis of the investigated tools that the fitness for use in practice often left much to be desired. The abundance of research knowledge from research institutes, which exists in the form of models, diagnostic and simulation tools, is insufficiently accessible and used. The integration of tools into farming practice is also sometimes hindered by their not being sufficiently known, by high investment costs and the poor accessibility of knowledge and data. An important aspect here is what financial value added is there to be obtained through the implementation of different tools. A major bottleneck is the integration of the various tools. Tools are often aimed at farming as a whole or they are highly crop-oriented. Because of inadequate adjustment (technical standardisation and standardisation of content) integrated usage of different tools is often difficult or impossible. Hence, in the new programme much attention will be paid to the development and implementation of an architecture for integration and standardization, depicted in Figure 2 in a simplified way.

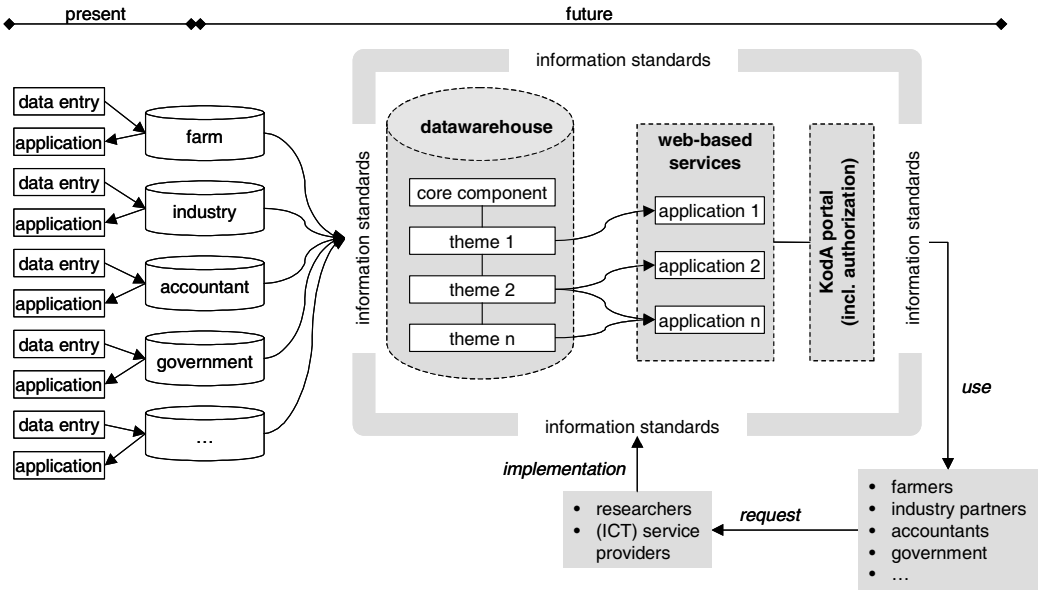

Figure 2 A simplified representation of developing an architecture for standardization and integration; further explanation in text

The left part of Figure 2 describes the present situation in which data are stored in isolated databases with one or more applications for management support on top of it. To develop integrated applications, which use more data sources at a time, data must be adapted to certain information standards. In a first phase, this adaptation can be done by conversion interfaces. Later on, these could be removed when data is directly entered according to the standards. However, this ideal situation will probably never be reached completely so that these interfaces will remain necessary. In the aimed situation at the right, applications should use standardized data only. Applications are based on components that contain theme-specific data and models. If applications use data from different sources, these must be available in time, so synchronization problems must be resolved. Using modern synchronization techniques, it is not necessary to store data in a central data warehouse, but for reasons of costs and efficiency it can be desirable. It is also desirable for research purposes when large amounts of data can be used and explored to develop knowledge that can be used for management support in the applications. For that reason, data quality also becomes an important issue. As the figure indicates, it is aimed that applications become web-based, because on-line applications and databases are easier to maintain and it provides possibilities to create one standard entrance, usually a portal, for users; appropriate authorization is a crucial prerequisite for that.

The elements in the lower right corner of Figure 2 describe the dynamics of the architecture. The group of users play a key role: together they define the requirements for the architecture and its contents. Researchers and (ICT) service providers play a secondary, although important role by implementing user's requests.

The information standard plays a crucial role in this architecture. Information standards define how business processes are supported by information and how the required information is represented: at the data level e.g. the units of measurement but also on a more aggregated level, e.g. how a crop revenue or a nutrient balance is built up. The idea is not really very new. Already in the 1980's it was tried to develop generic information models and partly they are incorporated in current management support systems, but without a 'live link' and no active maintenance of the central information model, so that it became obsolete, resulting in local, isolated standards in the present systems. Current trends like food safety, administrative burden and professionalization of entrepreneurship in a knowledge-based economy create a sense of urgency to develop and implement this architecture. Besides, new technical developments like Service Oriented Architecture, Model Driven Architecture and Enterprise Application Integration (including bus technology) make things much easier to attain, although it is realized that organisational change and co-operation is a critical success factor of much more importance.

5. Discussion and conclusions

In this paper we stated that the ever-more turbulent business environment requires fast and effective innovation. Business innovation is complex due to the many interdependent dimensions of the innovation object. It can be related to products and services (including its inherited attributes and market proposition) and the entire system that generates the products. The ability to manage complex innovation is an important factor to survive, or better to succeed in the volatile environment. We proposed that the distinction between incremental and transformational innovation is of vital importance for effective innovation management. It was found that the incremental evolutional approach of continuous improvements in small steps and the transformational revolutionary approach of periodic radical and fundamental changes are not contradictory, but reinforce each other. Both should be integrated and embedded dynamically in the entire organisation. In order to realize this, incremental and transformational innovation processes were elaborated in two connected, interacting and iterative cycles. Next we argued that ICT has an important enhancing role in both innovation cycles, as well as in connecting them smoothly. It provides valuable tools to capture, structure and communicate the required information and thus making complexity manageable for human mind. Finally, the case study showed that innovation is supported optimally if individual tools are integrated and used actively in an overall, component-based, flexible and open ICT framework. Information standards play a central role to enable component integration, to manage data integrity and to provide a common language.

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