



Working Paper Series

Continuous Innovation Managing Dualities through Co-ordination¹

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1. This working paper is an improved version of a paper presented at the 7. Fachtagung der Kommission Technologie und Innovationsmanagement im Verband der Hochschullehrer für Betriebswissenschaft e.V., Erfurt, 27-29 October 2005.

Background

In ever more industries, customers demand a high variety of fair-priced but high quality, increasingly customised or even unique products, delivered quickly and on time (see e.g. Bolwijn and Kumpe 1998). Consequently, companies are increasingly required to combine *operational effectiveness* and *strategic flexibility*. An organisation is operationally effective if it satisfies *today's* customers in terms of function, price, time, quantity, and place (Boer 2001, Boer and Gertsen 2003). Operational effectiveness is based on *exploitation* (March 1991, Boer 2001) capabilities², which are embedded in the organisation's configuration of products, market approaches, processes, technologies, competencies, organisation and management systems. An organisation is strategically flexible if it is able to develop new configurations of products, market approaches, processes, technologies, competencies, organisation and management systems that enable the satisfaction of (*the-day-after-*) *tomorrow's* customers (Boer 2001). Strategic flexibility is based on *exploration* capabilities (March 1991, Boer 2001, Boer and Gertsen 2003).

Combining excellence in operational effectiveness and strategic flexibility requires companies to go beyond continuous product innovation (Bartezzaghi *et al.* 1997). They will need to develop what we would like to call *continuous innovation* capability, to enable the effective, ongoing interaction between operations, incremental improvement and learning (exploitation processes), and radical innovation and change (exploration processes).

Many highly reputed scholars in areas such as innovation, manufacturing strategy and corporate strategy maintain that organisations can be good in one of the extremes embedded in the concept, not both:

- Burns and Stalker (1961): mechanistic management systems prosper in stable conditions, while organic systems perform better in changing conditions.
- Skinner (1974): '*[a] factory that focuses on a narrow product mix for a particular market niche will outperform the conventional plant, which attempts a broader mission*'.
- Porter (1980): there are three either/or strategies: cost leadership, differentiation and focus. Companies pursuing these strategies have very different characteristics. It is impossible to combine them organically in one system without losing competitive edge.

There is a lot of empirical evidence suggesting these authors are right. In the words of March (1995):

'[a] system that specializes in exploitation will discover itself becoming better and better at an increasingly obsolescent technology. A system that specializes in exploration will never realize the advantages of its discoveries ... Exploration and exploitation are linked in an enduring symbiosis ... Each interferes with the other ... [and] organizations persistently fail to maintain an effective balance between the two'.

However, increasing market and competitive pressure combined with progress in terms of technology (especially ICT), organisational models and managerial systems have led an increasing number of scholars to suggest that continuous innovation is not as unrealistic as many assume it to be. Even more, the few authors (e.g. Bolwijn and Kumpe 1998) pleading for the *need* to develop organisational forms that allow for continuous innovation have gradually gotten company of authors actually showing that this capability may well become possible. That is, they provide evidence of companies clearly on their way to develop continuous innovation capability and show how these companies are doing so.

The objective of this paper is to sketch part of the continuous innovation state-of-the-art, based on work published by others as well as our own research. In our experience there are three key questions related to continuous innovation capability:

- What are the design characteristics of continuously innovative companies?
- Is continuous innovation capability good for all companies?
- How can companies develop continuous innovation capability?

2. "Exploitation includes such things as refinement, choice, production, efficiency, selection, implementation, execution". "Exploration includes things captured by terms such as search, variation, risk taking, experimentation, play, flexibility, discovery, innovation" (March 1991).

We will focus on the first question and try to show that continuous innovation is primarily concerned with the ability to cope with a range of dualities. We will argue that it is fruitful to approach the study of that ability from an information processing and, within that, a co-ordination perspective.

Continuous innovation capability

What are the key characteristics of continuously innovative organisations? Stacey (1992) provides a first clue:

'When we look at the world of organizing ... you do not see "either/or" choices. Instead you see "both/and" choices. Successful organizations – that is, continually innovative organizations – cannot choose between tight, formal control systems and structures on the one hand and loose, informal systems that provoke learning on the other ... they must do both at the same time'.

We identified several relevant lines of publications addressing continuous innovation capability.

Publications on *industrial development* (e.g. Kenney and Florida 1987, Bolwijn and Kumpe 1998) have shown that industrial paradigms change from time to time. On a very long time horizon, we saw the emergence of Fordism (Mass Production) in the early 20th century. After a long period of continuous improvement (called rationalisation), Galbraith (1958) declared that production was not a real problem anymore and around the same time, Western industry started to focus on other things – manufacturing disappeared from the agenda of top managers. In the meantime, a new paradigm was in the making: Toyotism (known today as Lean Production). Fordism focused on cost, albeit through local, rather than global, optimisation, and enabled companies to produce reasonable quality. Toyotism enables companies to produce low cost, high quality products quickly and reliably. In other words, Toyotism performs better in traditional performance areas (cost, quality) and adds good performance levels in terms of speed and reliability. According to Bolwijn and Kumpe (1998), innovativeness is the next performance area companies will integrate successfully in this portfolio, requiring the support of what they call the innovative firm and what we prefer to call the continuously innovative organisation.

One of the first *operations management* studies actually showing the emergence of continuous innovation capability in industry was based on an analysis of data collected through the first International Manufacturing Strategy Survey (IMSS-I). The data showed that 83 (19%) of the 443 firms participating in the study were strategically flexible firms (Spina *et al.* 1996)³. These firms combine multi-focusedness, process ownership and process integration. Compared to firms that had adopted none or only one or two of the three characteristics, strategically flexible companies are consistently better in their:

- Improvement capability on a wide range of operational performance criteria (i.e. operational effectiveness).
- Ability rapidly to shift competitive and manufacturing priorities from one set of goals to another (i.e. strategic flexibility).

Yet another category of publications concerns the *learning organisation* (e.g. Senge 1990, Swieringa and Wierdsma 1992, Leonard 1998), a concept which may also provide a way to combine the two capabilities.

Organisation theory has valuable insights to offer, too. Recently, Sutcliffe *et al.* (2000) presented an *'... evolution of [singular, binary and dual] organisational process models'* and the antithetical, orthogonal and synergistic perspectives on balancing processes related to these models. According to Boer (2001), the three approaches actually represent a *'continuum'* related to the exploitation and exploration needs of an organisation (see Figure 1).

3. Spina *et al.* (1996) used the term strategic flexibility to encompass operational, improvement and innovation, i.e. exploitation and exploration excellence! Our definition would only include incremental and radical innovation or exploration excellence.

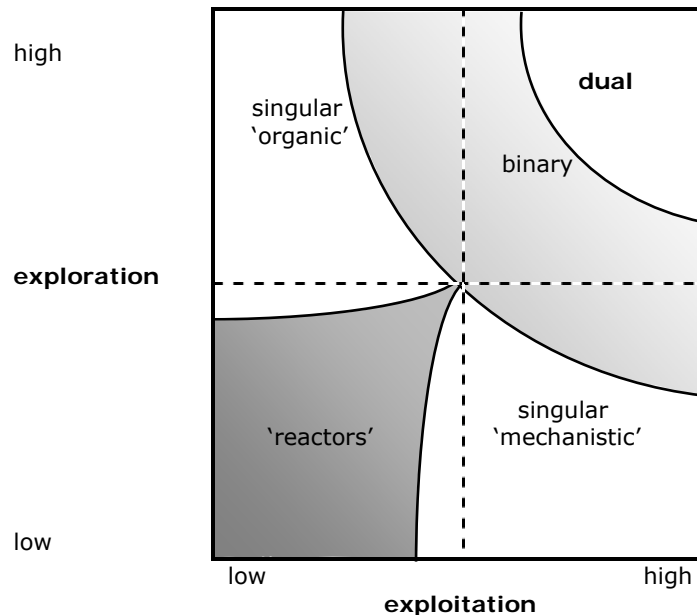


Figure 1: The relationship between exploitation and exploration needs and form of organisation (Boer 2001).

The bottom-left class depicted in Figure 1 includes Miles and Snow's (1978) reactors. The two singular cells comprise the mechanistic and the organic models of organisation (*cf.* Burns and Stalker 1961).

The binary model

From a continuous innovation perspective, the reactors are irrelevant. Much more interesting are the binary and, especially, the dual forms. *Innovation theory*, another discipline concerned with continuous innovation, suggests that while binary organisations balance demands for exploitation and exploration in an orthogonal way, dual organisations do so synergistically. Examples of the binary model would be:

- The ambidextrous organisation (Duncan 1976), which can behave organically when the situation calls for the initiation of new ideas, and in a mechanistic way to implement and use the ideas.
- The punctuated equilibrium model (Romanelli and Tushman 1994), which "*assumes that long periods of small, incremental change (i.e. product and/or process innovations) are interrupted by brief periods of discontinuous, radical change*".
- Imai's innovation process model in which radical systemic change is followed by long periods of maintenance and incremental improvement (Imai 1986).

These three models use 'time' as the separator of the mode of working. The organisation can oscillate, but switching mode not only takes time – various studies of changes in dominant design have shown that not many organisations have actually been able to cope with 'punctuations' successfully.

The functional structure, prevalent in most organisations, is not based on 'temporal' but on 'spatial' separation, and has co-existing subsystems of operational effectiveness and strategic flexibility operating at the same time, but in different places. However, the functional structure has its problems, too, in particular in the areas of response time to environmental changes, horizontal co-ordination between departments, and innovativeness.

The dual model

It is much less clear how much we know about the dual model. Until recently, the most elaborate theories on organising for a synergistic balance between short-term oriented operationally effective exploitation and longer-term strategically flexible exploration were those on the innovative firm (Bolwijn and Kumpe 1998), strategically flexible production (Spina *et al.* 1996), and the learning organisation (e.g. Senge 1990, Swieringa and Wierdsma 1992, Leonard 1998). Common characteristics of the three theories are:

- They position their 'ideal' firm in a context characterised by a dynamic market requiring a multi-focused strategy and ongoing changes in competitive priorities. The firms maintain an open and warm relationship with their environment (customers, suppliers).
- They maintain that the balance between exploitation and exploration is achieved by stability, action 'in the system', and improvement of a wide range of operational performance aspects, on the one hand, and renewal, reflection 'on the system', and innovation supporting the continuously changing competitive priorities on the other.
- They agree on decentralisation, empowerment and teamwork as the main organisational building bricks.

So, where are we?

Insightful as they are, the theories presented above share a number of weaknesses:

- The level of detail of the key characteristics is low. The theories are concepts, providing 'blueprint' direction rather than directly usable knowledge. With the exception of the strategically flexible production paradigm (Spina *et al.* 1996), they lack empirical underpinning. The literature on learning organisations, for example, is mostly anecdotal, based on just a few cases, e.g. Chaparral Steel (Leonard 1998) and Xerox Corporation (Senge 1990, Brown 1991), and the normative theories presented have hardly been validated rigorously (Gieskes 2000).
- The synergy of exploitation and exploration is addressed, but in a non-conclusive way. Bolwijn and Kumpe (1998), for example, prophesy that '*these companies have struck a balance between ...*', but fail to address in any detail how and to what extent the implementation of their recommendations will contribute to that.
- It remains unclear whether the organisation proposed is actually dual, binary or perhaps a hybrid of the two.

In spite of their weaknesses, these theories make one thing clear: continuous innovation capability is the capability successfully to manage the dualities of:

- Operational effectiveness and strategic flexibility.
- Exploitation and exploration.
- Stability and renewal.
- Action in the system and reflection on the system.

A recent publication edited by Pettigrew *et al.* (2003) and based on empirical research has added a range of dualities, in particular cultural, work organisation, leadership and management, and HR dualities (Sánchez-Runde *et al.* 2003), and heterogeneity-homogeneity dualities (Achtenhagen and Melin 2003). The book provides a wealth of examples of the way successful companies manage these dualities.

Finally, Maidique and Hayes (1984) refer to the 'paradox' of continuity and chaos, and provide six 'themes', that is, mechanisms, companies can use to manage this paradox successfully: business focus, adaptability, organisational cohesion, entrepreneurial culture, sense of integrity, and hands-on top management.

Continuous innovation – managing dualities

So, continuous innovation is not entirely '*terra incognita*' anymore. However, a coherent theory on the phenomenon is still wanting. Our objective is to contribute to the development of such theory by focussing on the question how to handle the dualities presented above effectively. One way of approaching that question is through recognising that continuous innovation is about co-ordinating and aligning or even integrating three key functions: operations – incremental improvement and

learning – radical innovation and change. It would, therefore, seem fruitful to look at continuous innovation from the perspective of co-ordination theory.

In the literature, various categorisations of co-ordination mechanisms have been proposed. See for example Galbraith (1974), Mintzberg (1979) and Daft (1992). All these authors focus on organisational co-ordination mechanisms. Taking a broader perspective, Paashuis and Boer (1997) propose and operationalise four categories of, what they call, integration mechanisms, namely strategic, processual, technological and organisational integration.

Managing dualities through co-ordination

Continuous innovation is the effective balance between exploitation and exploration or, in day-to-day terms, between operations – incremental improvement/learning – radical innovation/change. The question is how to achieve and maintain that balance. We use the four categories proposed by Paashuis and Boer (1997) to develop a tentative answer to that question. The examples we use to illustrate that answer are all based on studies in which the present authors have been involved. All the companies referred to, are on their way to develop continuous innovation capability – none of them, however, have achieved continuous innovation maturity. Consequently, this section does provide partial insight; it does not (and cannot) show the whole picture. Some of the examples will be positive, that is, indicate a positive effect of co-ordination; others will be negative, and indicate the effects of lack of co-ordination. Based on the discussion following the next section, we will propose suggestions for further systematic research.

Co-ordination through strategic alignment

Strategies and goals serve various purposes. They give sense of direction, motivate, act as guidelines for decision-making, and provide a standard for assessment. If well and unambiguously communicated, goals and strategies have great co-ordinating influence on the behaviour of (groups of) employees.

Bicycle Tyres had just redesigned its plant for cost-effective mass manufacturing in an effort to beat Asian competition. With bikes rather unexpectedly becoming a fashionable product, some customers no longer wanted cheap standard tyres any longer, but high-quality tyres with colours and profiles matching their bikes. In response to that, the design department started to overload the plant with new designs. The plant was not able to cope with that. Mutually inconsistent R&D and manufacturing strategies led to quality and delivery problems together with huge efficiency losses to the extent that the company went into the red figures.

Co-ordination through process integration

In our research, we did not find any examples of process integration. Interestingly, Paashuis and Boer (1997) did not either. There may be various explanations for this 'finding'. The most likely ones are:

- Processes or, rather, activities are integrated on the level of individual jobs. In higher units of analysis (group, organisation, network) they are co-ordinated and aligned, using strategic, technological and organisational mechanisms.
- Some processes, especially operations (manufacturing, assembly) and innovation (R&D, NPD) are so different, that they cannot be integrated effectively. However, this does not necessarily hold for incremental improvement and operations or, for example, learning in NPD (Bartezzaghi *et al.* 1997).

Co-ordination through technological integration

One way of looking at technology is through the lens of knowledge. From that perspective, technology is knowledge embedded in:

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- People: the knowledge, skills, experience, people use to perform activities. We call this humanware.
- Methods and techniques. We call this software.
- Plant, equipment, tools and infrastructure. We call this hardware.

Humanware

Important co-ordination-related aspects are:

- Knowledge of operations, improvement and innovation.
- Social, managerial, team skills.
- Attitude towards cross-boundary (cross-functional, inter-organisational) co-operation.

The R&D engineers of AgriSystems had an explicit negative attitude towards early involvement of production (parts manufacturing, assembly) in the product development process. The very positive attitude of the Production Manager – who understood the need for the company to move to a concurrent engineering mode, and had managed to convince the Managing Director (MD) of the benefits of that, did not help, as the MD, who was also interim R&D Manager at the time, did not have the skills (and the time) to convince the R&D engineers. Consequently, R&D kept bombarding Production with newly designed and re-designed parts, which led to huge stocks of spare parts and fixturing tools (many of which obsolete), as well as nervousness-related efficiency and quality problems.

Software

Organisations use of lot of methods and techniques, many of which actually have an integrating effect. Examples include:

- Quality Function Deployment (QFD), which requires the marketing, design and production functions jointly to develop product specifications.

Electronics Devices benefited considerable from the introduction of QFD, which especially improved the interaction between the marketing and design functions considerably. The CINet surveys held in 1996 and 2003, clearly showed the influence on CI performance of the use of CI tools supporting shopfloor employees analyse and solve improvement problems.

- The whole range of Design for ... (DfX) methods, which requires that manufacturing, assembly, packaging and distribution aspects are considered early on in the product development process.
- Teleconferencing and NetMeeting, which allow spatially separated functions to communicate intensively.
- A whole range of continuous improvement (CI) tools, helping shop floor people identify and understand improvement potential in their day-to-day practices (Boer *et al.* 2000).
- Performance management. Strong especially when it is based on Policy Deployment, so that groups and employees at all levels in the organisation work within a clear set of performance objectives that are directly derived from corporate strategy.

Over a period of ten years or so, the owner of Logistics had bought ten companies providing forwarding, transportation, warehousing and/or distribution services. When he started he already owned two companies, one of which he had inherited from his father; the other he had established himself. Although the operational performance of ten of the twelve companies was better than the average in their industry, the owner recognised that this was not enough – if he would not turn his 'collection' into a group of companies that worked together, improved continuously and developed new, innovative services, the group would not survive on the long term. He instigated a change programme aimed at slowly turning his 'collection' into a continuously innovative group – a key ingredient of that is a performance management system, which helps him and his middle management (the managing directors of the twelve companies) monitor and manage the change process and its effects on the continuous innovation performance of the group.

Hardware

Hardware technology includes plant, equipment, tools and infrastructure. Examples of hardware helping companies improve the communication and, thus, the collaboration between people include computer networks (ICT infrastructure), and office and shop floor layout. Whereas the ICT-

infrastructure does not have direct effects, as it is actually computer *software* that allows people to communicate, layout does. Well-known examples in manufacturing and assembly environments include cellular manufacturing and u-shaped production lines, both of which have positive effects on shop floor level CI. There are other examples, though:

AgriParts has a widespread and intensive CI programme in place. Scattered through the plant are dedicated, well-equipped CI areas, which offer the employees space and everything else they need to work on improvement projects whenever they can.

Organisational co-ordination mechanisms

Integration using organisational mechanisms is the best-reported category. The following, not necessarily exhaustive list (based on Galbraith 1974, Mintzberg 1979, Daft 1992, Paashuis and Boer 1997), presents a continuum of mechanisms, ranging from informal to formal, and from temporary to permanent. Furthermore, they also differ in terms of function-oriented versus process-oriented:

			function-oriented	process-oriented
Direct, face-to-face communication	(mostly) informal	(mostly) temporary		✓
Liaison roles				✓
Task forces and project teams				✓
Role combination	(mostly) formal	(mostly) permanent		✓
Secondment				✓
Co-location				✓
Hierarchical referral			✓	
Add positions to the hierarchy			✓	✓
Standardisation and formalisation		✓		
Full-time integrators			✓	
Matrix structure		✓	✓	
Standing committees			✓	
Self-contained groups			✓	

Figure 2: A continuum of organisational co-ordination mechanisms.

In all the studies we were involved in, we found the application of many of these organisational mechanisms. Most of the companies we worked with were on their way to improve their continuous innovation capability – none of them had achieved full maturity. All companies are still best characterised as having a binary organisation dominated by spatial, that is, functional separation.

In order to smoothen the introduction of new designs into the company's manufacturing and assembly plants, Pumps has a New Product Introduction function (or process, as they call it). In each new product development project, experienced operators are involved who gradually take over the responsibility for the project until after launch in production. Although they do not call this a function, Robots does exactly the same. Foremen representing production and also marketing, quality and logistics are formally involved in NPD projects. This practice is a response to all kinds of new product related problems in manufacturing the company experienced previously, when development and manufacturing each lived their own lives.

Most companies relied on rather traditional forms of co-ordination: direct communication, liaison roles, especially between production preparation and production, but also between design and production.

Furthermore, rather extensive use is made of task forces, project teams and standing committees (albeit mostly within R&D or design – much less so on an inter-functional level), hierarchical referral, positions added to the hierarchy, standardisation and formalisation.

In addition to developing a performance management system that helps the company monitor and manage the transition from an operationally effective collection of companies to a continuously innovative group providing logistical services, Logistics has also added positions to the hierarchy, experts in strategy, ICT, organisation and project management. These experts are *not* responsible for the change process – the twelve site managers are, together with the top management – they are only meant to provide advice as and when required.

We did not find any company using full-time integrators, while role combination was at best rare, although there are exceptions. One of the first innovation roles ever addressed in the literature is the champion (Schon 1963):

The continuous improvement (CI) champions at Lighting, assembly operators who 'burnt' for CI, played a key role in the company's very successful CI programme. When sales 'threatened' to exceed production capacity, the company decided to build a second plant. The new plant involved a radical processual, technological and organisational innovation for the company, and its development and construction absorbed a lot of managerial attention. The 'old' factory hardly suffered – the CI champions took care of that. However, near the completion date, they were transferred to the new plant in order to solve the last teething problems. This went quite successfully. However, not only the CI performance but also the operational performance of the 'old' factory suffered dearly.

Cars is among the few companies in our sample that has made successful use of secondment.

At Cars, the exchange of employees between different (plant) locations shows an extreme valuable outcome in terms of continuous improvement and innovation. Especially the growing trust in each other leads to better process efficiency. The international training programme deployed at the company allows employees from abroad to participate in specific functions such as development or controlling, for up to one whole year. The purpose is for these employees to gain insight into the relevant processes and actively taking part in a project (preferably in connection with the foreign location). Cars also encourages its homeland employees to pick up core positions abroad, like plant or quality manager. These expatriates have to share their knowledge and broaden the viewpoint of local employees. Specifically when a new model is to be ramped-up, many expatriates are transferred to the relevant location for a limited time frame – both from operations and development to foster exploitation and explore further engineering potentials for future car models (= "cross learning"). Feedback of this knowledge to basic R&D as well as vehicle engineering in its initial stages enables Cars to avoid failures made previously.

Co-location is not a widely spread practice either. This may be due to the fact we worked mostly with relatively small companies. We did not come across companies using matrix structures. Self-contained groups are not widely used either, but we did find a couple of examples.

In its 'old' factory Lighting had developed its shopfloor organisation to a fairly successful group of relatively autonomous teams, responsible for most of the execution, day-to-day management and continuous improvement of their own set of assembly tasks, increasingly including contacts with customers. Pumps is in the process of taking this a step further by gradually implementing the mini-factory concept in one of its parts manufacturing and one of its assembly plants. As the parts manufacturing plant is one of the main suppliers of the assembly plant, the two production managers involved are working very closely together to align their initiatives.

In fact, self-contained groups present the mechanism closest to the dual form of organisation. However, the Lighting and Pumps examples mentioned above concern a dual organisation of operations and improvement, not of (either of) these two functions and radical innovation.

Discussion

This paper addresses continuous innovation, defined as the effective, ongoing interaction between operations, incremental improvement, learning and radical innovation aimed at combining operational effectiveness and strategic flexibility through excellence in exploitation and exploration. According to an increasing number of authors, leading companies will get ever closer to this capability. This presents a dilemma to other companies in their industries: do we follow or, rather, focus on exploitation *or* exploration excellence, not both. Whatever choice they make, pursuit of excellence presents a huge challenge.

Detailed knowledge on how continuously innovative organisations might look like is rare, but two models seem to prevail: the binary type and the dual type of organisation. The common characteristic of both models is that they have found ways to manage dualities, that is, seemingly conflicting requirements, effectively. The difference is that they do so in different ways. The binary model separates exploitation and exploration spatially and/or temporally, whilst the dual organisation combines the two capabilities at the same time all the time.

It seems that the binary form currently prevails. However, organisations are clearly looking for ways to work towards the dual form. This road is not without barriers, though, and the question is if duality (in the sense of spatial and temporal integration of exploitation and exploration) is achievable at all. Attempts such as (elements of) concurrent engineering, in particular collocation in order to achieve alignment of functions involved in NPD, have been applied successfully in industry. Team-based continuous improvement presents another successfully applied example.

However, all these attempts are still very partial, combining elements of exploitation and exploration, but not all of the two concepts, and it may actually well be that the purely dual model is a bridge too far. A better approach might be for organisations to manage their position on the binary-dual continuum dynamically and in so doing to use a rich set of mechanisms. That is, to situation-dependent (dynamic management) use strategic, processual, technological and organisational co-ordination mechanisms.

Strategy can, and technology must, be kept in place much longer than process and organisation. That is, it makes sense not to change strategy every day while capital-intensive technology cannot be replaced every day. (Some) organisational arrangements can, though. The literature and our own experience suggest various ways of achieving co-ordination using strategic and technological mechanisms. Both kinds of mechanisms therefore seem to present a useful addition to the organisational mechanisms prevailing in the literature. We did not find good examples of process integration, other than, predominantly, shop floor employees (operators) also responsible for CI activities. Two, not necessarily competing, explanations of this are related to unit of analysis (real process integration is most likely found on the job level) and differences between process characteristics disabling process integration and asking for the use of other (strategic, technological, organisational) mechanisms instead. We will address each of these explanations in more detail below.

The working hypothesis this paper is based on, namely that it is useful to look at continuous innovation through the lens of co-ordination theory, seems to be confirmed, but a lot of further research is needed to develop a coherent theory of continuous innovation (see below).

Looking a bit behind the immediate findings presented in this paper, we found that process characteristics seem to have an effect on the choices made by companies and their success:

- The relative frequency of exploration – the higher that frequency, the more affordable it is to design a function bridging innovation and operations. Pumps and Robots are examples of companies with a constantly high new product introduction rate, and they handled the interaction between design and manufacturing successfully. At Bicycle Tires, the speed to which the R&D department reacted to the new fashion came so suddenly and unexpectedly for production (R&D had made no effort to set up any form of co-ordination with production), that production was simply overcome.
- The flexibility of production – the higher that flexibility, the easier it is to follow the effects of explorative activities. Even if the R&D department at Bicycle Tires had communicated its change in new product development activities, it would still have been very difficult for production to follow, as the plant had just put considerable investment into developing mass manufacturing capability.

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- The frequency of innovation is related to type and radicality. In all the companies we presented here, product innovation was by far the most frequent exploration activity, followed by process and organisational innovation and, finally, market innovation. Most product innovations were relatively incremental in nature – modifications (improvements, customisation) to existing products, whereas some of the process and organisational innovations were much more radical in their effects. As the introduction of Concurrent Engineering at AgriSystems, an example in place, suggests, one-off radical innovations are much more difficult to handle than high frequency incremental innovations.
- The professional difference between competences required for successful exploitation and exploration – the smaller that difference, the easier it is to integrate these activities in individual functions; integration of continuous improvement in the day-to-day work of individuals, whether on the shop floor or in other functions (e.g. design), is an example in place.

Finally, the mechanisms companies (can) use to integrate exploitation and exploration in order to move from a binary model towards a higher level of duality much depend on the unit of analysis:

Unit of analysis	Constituent task	Organisational model and solutions to increase duality
Supply network	Organisational task	Usually a, not necessarily quite effective, combination of exploitation and exploration. Co-ordination requires collaboration between firms in increasingly dynamic networks. Key question are: How can continuous innovation be developed on the level of networks? What are the implications for network 'division of labour' and co-ordination? Are we going to see partners ever more specialised in exploitation or exploitation, which have 'plug-and-play' capability to cope with network dynamics? What will be the role of 'communities of practice'? And of ICT?
Organisation	Group task	Most organisations still have an essentially functional structure, that is, groups (departments) usually have a functional task. Consequence: spatial separation between the tasks of different groups and, thus, a binary organisation. Solutions to achieve a higher level of duality: <ul style="list-style-type: none"> ▪ Strategic alignment: an externally consistent corporate strategy and internally consistent functional strategies; strategy deployment; performance management. ▪ Process integration: probably not applicable on inter-functional level. ▪ Technological integration: CAD/CAM; DfX, FMEA, QFD; web meetings, teleconferencing. ▪ Organisational co-ordination and integration: widely-spread mechanisms are direct (face-to-face) communication, liaison roles, task forces and project teams (temporary), standing committees, in addition to hierarchical referral, positions added to the hierarchy, standardisation and formalisation. There is some evidence of the use of self-contained groups. Secondment, co-location, full-time integrators, self-contained groups and matrix structures are rare.
Group	Individual task	Most organisations still have an essentially functional structure. Consequently, individuals within groups (departments) have similar jobs (exploitation or exploration, not both) as well. Consequence: singular organisation, also on group level. Widely applied intra-group co-ordination mechanisms are direct (face-to-face)

		communication, standardisation and formalisation. Solutions to achieve a higher level of duality include secondment and re-grouping to, for example, self-contained groups (e.g. mini-factory).
Individual	Subtask	Most people have 'singular' job designs. That is, their job is dominated by either exploitation or exploration type of activities. Solutions to achieve a higher level of duality include role combination, job enlargement and enrichment and, through that, process integration (!).

Figure 3: The relationship between unit of analysis and the co-ordination mechanisms

Conclusions

The approach taken in paper starts from the definition that continuous innovation is the capability, in performance terms, to combine operational effectiveness and strategic flexibility effectively. In process terms, continuous innovation is the capability successfully to combine exploitation and exploration or, in more operational terms, operations, incremental improvement/learning, and radical innovation/change. The interest in continuous innovation is booming. The term "continuous innovation" scored 29,500 hits in a Google search in June 2004 and 213,000 hits in September 2005 - an increase of over 700% in just under a year.

At the same time, however, deep knowledge of the phenomenon is still largely lacking. Key questions currently unanswered include:

- Is continuous innovation good for all companies? Probably not, but then, what factors determine which companies should go for this capability, and which companies are better off focusing on exploitation *or* exploration, not both.
- Then, what do continuously innovative organisations look like in terms of processes, technology, people, organisation and management?
- And, what can we learn from the change process companies that successfully developed continuous innovation capability went through?

One paper is not nearly enough to address all these questions. We focused on the first question and argued that, in combining operational effectiveness and strategic flexibility through excellence in both exploitation and exploration, co-ordination, alignment or even integration of these two types of process is a key factor. We presented and illustrated using examples based on various studies in which we have been involved, a list of strategic, technological and organisational mechanisms companies may use to achieve the balance pursued. A key word describing organisational life is interaction: organisations interact with other organisations and are comprised of groups and individuals interacting with each other. We therefore presented our analysis recognising four units of analysis, the network, the organisation, the group, and the individual.

The analysis suggests that some co-ordination mechanisms are unit-specific (e.g. job enlargement and enrichment), others are much more generic (e.g. strategy deployment). This suggests that any analysis of the role of co-ordination (alignment, integration) should be explicit as to the unit of analysis addressed.

Limitations and further research

There are various limitations to the study, which provide directions for further research at the same time.

First, it may actually make a lot of sense to distinguish between co-ordination, alignment and integration. One way of looking at the three terms is:

- Alignment – situation, state of strategic being.
- Co-ordination – process, state of strategic and/or organisational doing
- Integration – structure, state of organisational being.

Second, we are sure the list is not exhaustive. Culture, for example, is missing and likely to provide a major co-ordination mechanism. Another mechanism attracting a lot of interest is that of so-called

communities of practice, which could also act, both within organisations and on the level of organisational networks, as the forum providing the quick and effective learning underpinning continuous innovation. Finally, there is a whole range of techniques, including for example the balanced scorecard, which support companies in their efforts to achieve co-ordination (through, in this case, strategic alignment). In-depth studies may help shed light on the application and effects of such techniques.

Third, none of the companies we have worked with so far has a fully developed continuous innovation capability. This implies two things:

- We do know that companies still use many of the established co-ordination mechanisms, while some of the more advanced mechanisms are rarely used. However, we cannot know, at this stage, whether, how and to what extent that will be different in companies with more mature continuous innovation capability.
- At this stage, we cannot be sure either about possible configurational effects. If an organisation wants to develop a more mature continuous innovation capability, does that require they add more advanced mechanisms to the set of established mechanisms they already have in place? Or do they have to replace these mechanisms and, then, which ones?

Fourth, we identified some contingencies that seem to affect choices companies can make. High frequency incremental product innovation allows companies to organise for intensive *collaboration* between that exploration function and more exploitative functions such as production and marketing. Full *integration*, however, may be impossible, as the professional differences between these functions are too big. In contrast, high frequency process improvement, whether on the shop floor or in other functions, may allow for real integration, of improvement tasks into the job of employees, as the professional difference between the daily job and the improvement activities focused on the direct working environment are much smaller. Low frequency radical innovations, whether they pertain to products, processes, organisation or markets, seem to be the most difficult category, and the question is whether it is at all possible to handle such exploration activities effectively in a dual mode. This leads to the following hypotheses:

Hypothesis 1: The larger the professional difference between competencies required to perform exploitation and exploration activities, the more likely we will find a binary organisation with the alignment of these activities arranged through inter-group level co-ordination mechanisms.

Hypothesis 2: The more frequent and the less radical the exploration activities, the more affordable it is for the organisation to co-ordinate using permanent mechanisms in a, consequently, dual organisation.

Hypothesis 3: The smaller the professional difference between the competencies required to perform exploitation and exploration activities, the more likely we will find a dual organisation with alignment of these activities arranged through job, intra-group (=inter-job) and inter-group level co-ordination mechanisms.

Hypothesis 4: The higher the flexibility of the exploitation activities, the lesser the need to co-ordinate the exploration and exploitation activities intensively.

Further research is needed to test these suggestions, identify if other contingencies are in play and, if there are, what role they play.

Finally, the continuous innovation research community has paid remarkably little attention so far to the role of 'the human factor' and the consequences of developing and maintaining continuous innovation capability for the Human Resource Management strategy and practices of companies. However, whatever the set of co-ordination mechanisms in place, synergy between exploitation and exploration can only be achieved if the right number of the right people are prepared to collaborate with each other. In other words, continuous innovation depends as much on capacity, competence and collaboration as it does on co-ordination. Dimensions playing a role here include:

- Level of staffing.
- Intellectual or cognitive capabilities: knowledge, skills and intelligence.
- Behaviour, which includes factors such as attitude, personality, values and personal objectives.
- Position, which refers to the responsibility and power base.

Insight into the links between these dimensions and continuous innovation capability is urgently needed.

References

- Achtenhagen, L. and L. Melin (2003), Managing the homogeneity-heterogeneity duality. In: Pettigrew, A.M. *et al.* (eds.) (2003), *Innovative forms of organizing. International perspectives*, Sage Publications, London.
- Bartezzaghi, E., M. Corso and R. Verganti (1997), Managing knowledge in continuous product innovation, Proceedings of the 5th International Product Development Management Conference, Como, Italy, May 25-27, pp.75-90.
- Boer, H. (2001), And [Jethro] said ... Learning: the link between strategy, innovation and production, Center for Industrial Production, Aalborg University, 4 May.
- Boer, H. and F. Gertsen (2003), From continuous improvement to continuous innovation: a (retro)(per)spective, *International Journal of Technology Management*, Vol. 26, No. 8, pp. 805-827.
- Boer, H., A. Berger, R. Chapman and F. Gertsen (eds.) (2000), *CI changes. From suggestion box to organisational learning. Continuous improvement in Europe and Australia*, Ashgate, Aldershot.
- Bolwijn, P.T. and T. Kumpe (1998), *Marktgericht ondernemen. Management van continuïteit en vernieuwing*, Van Gorcum, Assen.
- Brown, J.S. (1991), Research that reinvents the corporation, *Harvard Business Review*, Vol. 69, pp. 102-111.
- Burns, T. and G.M. Stalker (1961), *The management of innovation*, Tavistock, London.
- Daft, R.L. (1992), *Organization theory and design*, West Publishing Company, St. Paul.
- Duncan, R.B. (1976), The ambidextrous organization: designing dual structures for innovation. In: R.H. Killman, L.R. Pondy and D. Slevin (eds.), *The management of organization*, North-Holland, New York.
- Galbraith, J.K. (1958), *The affluent society*, New American Library, New York.
- Galbraith, J.R. (1974), Organization design: an information processing perspective, *Interfaces*, Vol. 3, No. 4, pp. 28-36.
- Gieskes, J.F.B. (2000), Organizational learning in product innovation: an information processing process in a contingency perspective", T&M research report 2000W-003 T&O-007, Faculty of Technology & Management, University of Twente, Enschede.
- Imai, M. (1986), *Kaizen. The key to Japan's competitive success*, Random House, New York.
- Kenney, M. and R. Florida (1987), Japan's role in a post-Fordist age, *Futures*, April, pp. 136-151.
- Leonard, D. (1998), *Wellsprings of knowledge*, Harvard Business School Press, Boston.
- Maidique, M.A. and R.H. Hayes (1984), The art of high-technology management, *Sloan Management Review*, Vol. 25, Winter, pp. 18-31.
- March, J.G. (1995), The future, disposable organizations and the rigidities of imagination, *Organization*, Vol. 2, pp. 427-440.
- Miles, R.E. and C.C. Snow (1978), *Organizational strategy, structure and process*, McGraw-Hill, New York.
- Mintzberg, H. (1979), *The structuring of organizations*, Prentice-hall, Englewood Cliffs.
- Paashuis, V. and H. Boer (1997), Organizing for concurrent engineering: an integration mechanism framework, *Integrated Manufacturing Systems*, Vol. 8, No. 2, pp. 79-89.
- Pettigrew, A.M. *et al.* (eds.) (2003), *Innovative forms of organizing. International perspectives*, Sage Publications, London.
- Porter, M.E. (1980), *Competitive strategy. Techniques for analyzing industries and competitors*, The Free Press, New York.
- Romanelli, E. and M.L. Tushman (1994), Organizational transformation as punctuated equilibrium: an empirical test, *Academy of Management Journal*, Vol.37, No.5, pp.1141-1166.
- Sánchez-Runde, C.J., S. Massini and J. Quintanilla (2003), People management dualities. In: Pettigrew, A.M. *et al.* (eds.) (2003), *Innovative forms of organizing. International perspectives*, Sage Publications, London.
- Schon, D.A. (1963), Champions for radical new inventions, *Harvard Business Review*, March-April, pp. 77-86.
- Senge, P.M. (1990), *The fifth discipline. The art & practice of the learning organisation*, Doubleday, New York.
- Skinner, W. (1974), The focused factory, *Harvard Business Review*, Vol. 52, May-June, pp. 113-121.

- Spina, G., E. Bartezzaghi, A. Bert, R. Cagliano, D.J. Draaijer and H. Boer (1996), Strategically flexible production: the multi-focused manufacturing paradigm, *International Journal of Operations & Production Management*, Vol. 16, No. 11, pp. 20-41.
- Stacey, R.D. (1992), *Managing the unknowable. Strategic boundaries between order and chaos in organizations*, Jossey-Bass, San Francisco, p.19.
- Sutcliffe, K.M., S.B. Sitkin and L.D. Browning (2000), Tailoring process management to situational requirements. In: R.E. Cole and W.R. Scott (eds.), *The quality movement & organization theory*, Sage Publications, Thousand Oaks (Cal.).
- Swieringa, J. and A. Wierdsma (1992), *Becoming a learning organization*, Addison-Wesley, Wokingham.