COMPARING QUALITY AND BUSINESS IMPROVEMENT METHODOLOGIES FOR COLLABORATIVE WORKING IN THE PRODUCT DEVELOPMENT PROCESS OF SMES

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ABSTRACT

This paper makes the case that of all of the improvement methodologies used in businesses, continuous improvement can overcome the problem of ossification in the context of new product development where the ability to engage in exploitation and exploration may be a prerequisite for business success in the future. In particular, indicators such as linking strategic objectives to improvement activity and degrees of integration of systems within and between firms have a close fit with the cultural dimension of continuous improvement, something which is largely absent from top down, output focused TQM and Lean programmes. The case is made on the basis of a review of a variety of literatures including those on TQM, Lean, continuous innovation, the extended manufacturing enterprise and bootlegging.

Keywords: CI, improvement methodologies, Lean, TQM, NPD, ambidextrousness.

1. INTRODUCTION

This paper reflects on the literatures on improvement methodologies (including TQM, Lean, Continuous Improvement - CI), Continuous Innovation, the Extended Manufacturing Enterprise (EME) and New Product Development (NPD). It is argued that TQM and Lean are explicitly top-down, programmatic, control-oriented and static in the context of process and product innovation. CI, by contrast, is bottom-up and, at certain degrees of maturity, inherently and methodologically reflexive. CI research has, however, tended to focus on manufacturing or routinised operations within businesses largely because traditional metrics exist to monitor effectiveness. Research into CI in the more creative functions – such as NPD – is inchoate. But even here, the agenda is changing. No longer are firms independent units of activity; the need to collaborate with suppliers, customers, and even public agencies must be factored into innovation management thinking and improvement initiatives.

The paper first reviews allied theoretical and practical concepts and issues around the notion of NPD, collaborative improvement (CoI) in the context of the extended manufacturing enterprise, and the challenge to become 'synergynistic' balancing the demands of exploitation and exploration. The paper then argues that applying TQM, Lean and CI tools and techniques here runs the risk of process and product ossification. Avoiding ossification is perhaps the compelling innovation management challenge of our time.

2. THE FORMAL VIEW OF THE NEW PRODUCT DEVELOPMENT PROCESS

Innovation studies indicate a number of 'good practices' in the NPD process. Implicit in this discussion is the focus on manufacturers (and generally not services). The following four good practice categories define a 'formal view' of the NPD process: appropriate NPD process structures; managerial implementation enablers; effective use of technology enablers such as CAD, effective linkages with other organisations; and practices that enable learning.

2.1 STRUCTURING THE NPD PROCESS

Wheelwright and Clark (Wheelwright et al., 1992) have conceptualised the NPD process as a funnel with three interlinked stages. The first stage entails the managerial practices needed to capture the signals or signposts from the external market place and the internally driven design, technological and scientific creativity that leads to new ideas (Rothwell, 1992). The second development stage transforms the concepts of the first stage and reworks them technically into a marketable product.

Development activities include engineering, testing, prototypes, market forecasting, design and production feedback. The final stage includes all the activities required for ramping-up for the market launch. Stages and activities overlap involving many players with a wide array of capabilities.

Augmenting this, Takeuchi and Nonaka's (Takeuchi et al., 1986) development model integrates in-house activities with early supplier and customer links. This so-called *rugby approach* directs activities in both series and parallel. Embracing small units whilst calling on expertise in broad teams and, where appropriate, other organisations. The process is accelerated when agents perform tasks simultaneously and when different players are brought together to address particular challenges. Optimising group and individual time in terms of expertise (and creativity) is the primary goal.

2.2 PROJECT TEAMS

Wheelwright and Clark (Wheelwright et al., 1992, pp. 188-217), tender four types of project team structures:

- Functional – consisting of members primarily linked to their particular function. Activities are undertaken sequentially with little overlap;
- Lightweight – where members belong to an organisational function with project work as an additional duty. This team will have a co-ordinating leader;
- Heavyweight – in which members are drawn from functions but project work becomes just as important as functional responsibilities. Team goals and objectives are emphasised. The team leader has control over project resources;
- Autonomous – where functional members are assigned to teams with the team leader becoming the sole authority over all resources. This team has latitude to explore and experiment with new ideas and concepts.

2.3 BOOTLEGGING

Whilst formal team-based product development is the norm, informal approaches are also evident and important. Bootlegging is defined by Augsdörfer (Augsdörfer, 1995, p. 18) as:

> …research in which motivated individuals secretly organise the innovation process. It usually is a bottom-up non-programmed activity, without the authorisation of responsible management, but for the benefit of the company. It is not in the department's action plan, nor is a formal resource allocated.

Augsdörfer confirms a number of causes. These include the failure of project managers adequately to resource slack that ordinarily enables experimentation and blue sky work; the need for upfront data to inform *formal* new research and new product development proposals; and autonomy for creative individuals and teams. Bootlegging, for firms, is a way of developing new product ideas with a low degree of investment uncertainty. Whilst it tends to be incremental product improvement, it is not exclusively so and has been demonstrated to include 'boundary spanning' activities and to challenge organisational path dependencies.

We have demonstrated that NPD is a dynamic and uncertain exercise. Systems and procedures have been created around it to ensure efficiency and outcomes (e.g. market launch). What is not clear is how these systems and procedures are updated and improved. How have improvement methodologies affected NPD? Indeed, are they philosophically suited to the task? Below we introduce three improvement methodologies: Continuous Improvement (CI), Total Quality Management (TQM) and Lean. However, first, we introduce the notion of loops of learning.

Single loop learning is adaptive learning where corrective action is taken on the basis of experience. It is concerned largely with meeting existing goals and objectives through process application (Argyris et al., 1978). It is largely non-reflexive and targets customer satisfaction. Double loop learning, by contrast, occurs when learning leads to a necessary challenge to underlying organization policies and objectives. For Flood and Romm (Flood et al., 1996), double loop learning is a reconciliation of tensions within single loop learning which arise out of its ideological underpinnings; i.e. it is unidimensional and linear. Double loop learning is both reflexive and non-reflexive, depending on the direction of view. Where two centres of learning face one another reflexivity is high; where the view is outwards, away from the centre, reflexivity is low (or there is double vision). Double loop learning employs quality management methods and the generation of structural arrangements within which processes flow. Triple loop learning goes a step further in developing the fullness and deepness of learning in the context of a need to manage diversity in creativity, human wellbeing and, by definition, the business interests of an organisation. Triple loop learning asks: are we doing things right, and are we doing the right things, and is rightness buttressed by mightiness and/or mightiness buttressed by rightness?

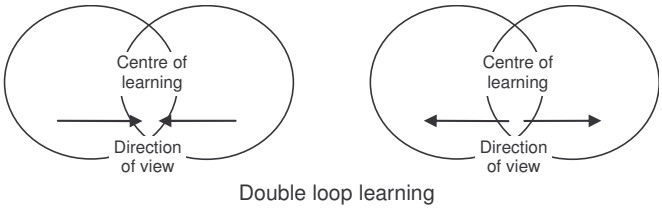
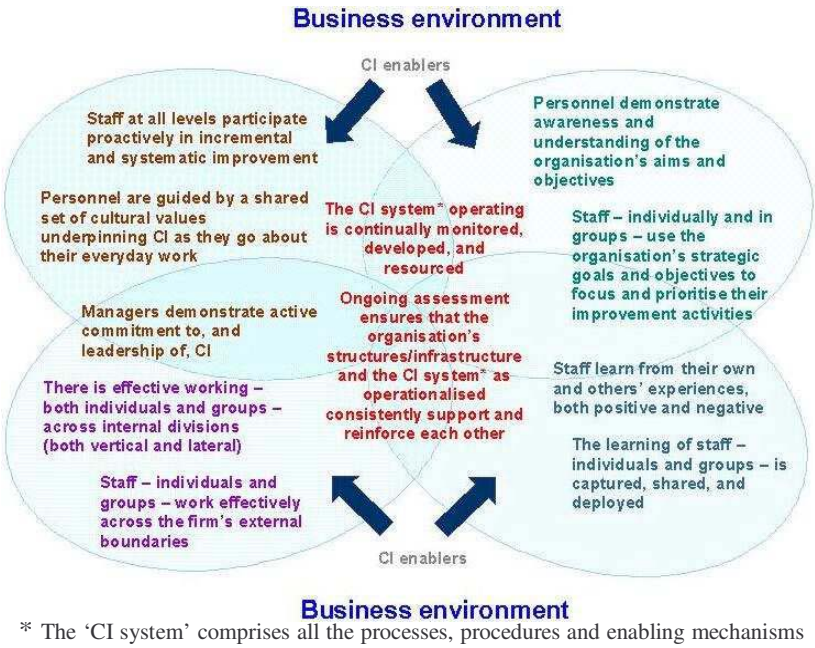


Figure 1. Directions of View for Double Loop learning (source: Flood & Romm 1996)

3. IMPROVEMENT METHODOLOGIES

3.1 CI

The origins of CI are inextricably bound up in industrialisation and the transition from artisanship to mass production. Taylorism fostered and refined mass production and relegated worker determined production methods. Deskilling ensued, exacerbating worker disenfranchisement and alienation. Schroeder and Robinson (Robinson, 1991) note Henry Gantt's call to reintroduce the worker into modern production methods, represents the source of modern CI thinking and programmes.



* The 'CI system' comprises all the processes, procedures and enabling mechanisms put in place to encourage the adoption of key behaviours.

Figure 2. Generic CI/Behaviours/routines

Ironically, it was the export of these methods *from* the United States *to* Japan after WWII that developed the modern techniques of *kaizen* that are its most recognisable aspects; for example, quality circles, zero defects and suggestion schemes. Critically, however, the difference between Western and Japanese management concepts is defined in terms of the West's preoccupation with innovation and results vis-à-vis Japanese emphasis on process (Massaaki Imai quoted in (Robinson, 1991, p. xxxi).

3.2 TQM

TQM is defined as a philosophy of management with customer and process orientations at its core (Hill et al., 1995). Taylor and Pearson (Taylor et al., 1994) (p26) define it as a managed system to achieve total quality. Total quality is a co-ordinated commitment to achieving quality at each stage of a product or service's life cycle. Almaraz (quoted in (De Cock et al., 1997, p. 660) stresses the need for TQM integration across a business at all levels. Essentially, TQM is not an 'add-on'. However, the concept itself is measured against its implementation success in businesses which, if the literature is representative of practice, has been less than auspicious (see Wilkinson et al., 1992). That said, often there are logical reasons for failure; for example, non-systematic approaches to

implementation leading to organisational paradoxes (Sterman et al., 1997), the need for quick results for managers leading to poor reflexivity (De Cock et al., 1997) insufficient resource given over to implementation (Redman et al., 1995), and poor understanding of organizational context such as levels of unionisation, plant size and plant age. Implementation is often advocated by managers of companies that are struggling financially; ultimately, the attraction of TQM is not unrelated to its functionalist ontology (delivery of efficiency and profit).

TQM is intrinsically top-down in its orientation despite its integral CI component (Hackman et al., 1995). The danger for advocates of TQM, consequently, is ossification. Ossification is rooted in three factors. First, a reliance on a linear cause-and-effect cognitive approach to implementation, is potentially too simplistic, non-holistic and of limited sustainability. Second, TQM promotes and hones organisational routines. Routines, however, lead to "individuals and groups [going] about their work mindlessly" (Hackman et al., 1995, p. 334). Benner and Tushman (Benner et al., 2003) go further in arguing "[a]ctivities focused on measurable efficiency and variance reduction drive out variance-increasing activities and, thus, affect an organisation's ability to innovate and adapt outside of existing trajectories" (p 242). In other words, enhancing the effectiveness of routines – particularly in upstream activities – leads to less exploratory activity which is ordinarily the source of radical product and process innovation. Third, is its control emphasis. Audits are conducted over existing procedures and waste is taken out in the form of unnecessary activity. TQM, therefore, becomes 'Taylorist' process control rather than enhanced outcomes (Spencer, 1994), leading to reduced performance and an inability to respond to opportunities when the environment changes.

However, TQM is continuing to develop a post-modern emancipatory/critical stream. In addition, external driving factors such as technology, markets and environment/sustainability are also being factored in (McAdam et al., 2004). Evidence of this is reflected, albeit belatedly, in international standards and methodologies such as ISO and EFQM – both of which can be used to facilitate reflexive and critical approaches to quality improvement. McAdam (McAdam, 2004) further argues that TQM should not stifle creativity and knowledge creation (quite the opposite) providing it is informed by social constructionism; namely, that those engaged in TQM programmes do so critically and reflexively. "[groups] share and agree the underlying assumptions of the knowledge created…" (p. 698).

3.3 LEAN MANUFACTURING

Lean, too, is explicitly top-down in its emphasis. Smeds (Smeds, 1994) identifies the critical lean manufacturing principle to be integrating "production activities into self-contained units along the production flow" (p. 69). More prosaically, Katayama and Bennett (Katayama et al., 1996) charactacterise lean as being production in which inputs in terms of resources are reduced (materials, parts, unproductive set-up time, etc.) and the pressures associated with improved performance (e.g. quality, technical specifications, product variety) are met.

Implementation is the Achilles heel of firms engaged with quality methodologies. The case of lean production provides useful insights. Womack *et al* (Womack et al., 1990) uncover the success factors of lean manufacturing through the example of Toyota in Japan after WWII. The first is the absence of mass production in Japan. In the US by contrast, mass production was the successor to craft-based production. This absence of mass production in Japan enabled the inaugural production method for the Japanese

motor industry to be a craft/mass production hybrid. Lean production, as it was termed, was not encumbered with legacy systems and a work culture defined in terms of hierarchy and the quest for high remuneration. The second was found in the organisation of the supply chain. Toyota, for example, was not a traditional vertically integrated firm. Rather, it subcontracted many design and production decisions to its suppliers and encouraged them not only to cooperate with one other, but also to improve their engineering processes (and indeed to hold each other's equity). Moreover, the subcontracting was not price dependent. Toyota brokered long-term contracts with suppliers in return for frequent just-in-time supply.

4. COLLABORATIVE ENTERPRISES, NPD AND IMPROVEMENT METHODOLOGIES

Increasingly manufacturing firms have experienced radical changes in their processes in light of the phenomenon known as the Extended Manufacturing Enterprise (EME) (Middel et al., 2004). In the context of CI the focus shifts from intra-firm activities (e.g. cross-functional CI) to inter-firm 'collaborative improvement' (CoI). CoI is defined as "a purposeful inter-company process that focuses on continuous incremental innovation aimed at enhancing the overall performance of the disparate companies within a network"(Middel et al., 2004). The difficulties of implementing CoI are explored in three regionally distinct EMEs by Kaltoft et al (Kaltoft et al., 2004). Critically, they demonstrate the importance of a period of learning for CoI groups in EMEs irrespective of their implementation approach; i.e. bottom up, top down or laissez faire (possibly through facilitated workshops). This learning will include building knowledge about CoI within the EME and active facilitation in knowledge development. In essence, there are a host of *cooperative competences* necessary for CoI (Kaltoft et al., 2004). Tyler (Tyler, 2001) links these cooperative 'capabilities' to process *and* product innovation; for example, increased co-ordination between design and manufacturing and greater supplier coordination. And critically, cooperative capabilities are largely non-tradable which means they, and their value-adding functions, tend to be imperfectly mobile and imperfectly imitable rendering them significant resources for individual firms and partners alike. The danger once again here is that businesses fall into *competency traps* persisting with inferior technologies (Locke et al., 1995).

Cooper et al (Cooper et al., 2003), moreover, focus on design innovation of the extended enterprise. They demonstrate through a series of case studies the importance of integrating designers – whether in-house or external – into all aspects of the project from concept through to production. In their process protocol, CI is one of eight key principles for generic design.

Panizzolo's (Panizzolo, 1998) methodology for lean improvement programmes relating specifically to product design, include: parts standardisation, product modularisation, design for manufacturability, phase overlapping, and multi-functional design teams. At the customer level – involvement in design and quality programmes tends to be low. This raises the possibility that the key challenge may well be *relationship* management rather than operations management.

4.1 CONTINUOUS INNOVATION

Boer and Gertsen (Boer et al., 2003) capture the essence of continuous innovation in the matrix below (Figure 3). Organisations that specialise in exploration or exploitation are categorised as singular 'organic' or singular 'mechanistic'. Ultimately, they will fail as singular mechanistic businesses have few new ideas to exploit; the singular organic organisations may have many new products but little in the way of competence in

realising their commercial advantages. Binary organisations, however, are those that achieve a balance between exploration and exploitation but are not 'synergynistic' in that they are not systemic in their view of both their core activities and the environment(s) in which they are carried out, unlike dual organisations.

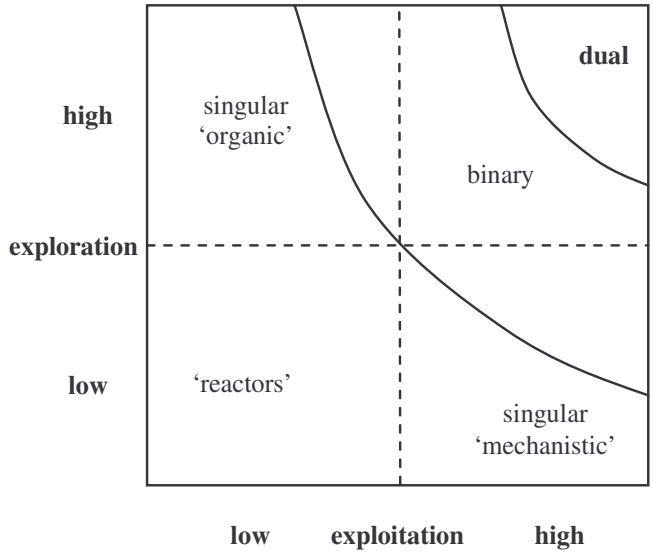


Figure 3. Continuous Innovation Generated by Dual Organisations

Benner and Tushman link exploration firmly with dynamic capabilities. Consequently, innovative organisations may need to become ambidextrous, by which they mean able to balance process innovation (and ultimately control) with more creative and contrasting architectures that foster exploration rather than embed mere exploitation. Critically, they argue that experimentation and variability has to be reconciled with process control and exploitation within and across organisations. Moreover, senior managers need to integrate strategically these 'units' into the fabric of the organisation.

4.2 IMPROVING THE NPD PROCESS

Improvements to NPD processes are not always intuitive. The work of MacCormack, Verganti and Iansiti is instructive. They studied a range of internet software products and the processes that delivered them to the market and demonstrated both the value of empirical research to inform improvements and how 'strict' NPD processes can lead to inferior products. Software products are not the same as heavier more tangible products – so the findings of this study may not be extrapolated. However, software products are modular and developed in uncertain and dynamic environments. There is also uncertainty about how the final product should look and function. The research teams engaged on software projects tend to leave the final definition of the product's architecture until very late in the development process, whilst rapidly and repeatedly allowing the customer an opportunity to trial the product (despite the absence of significant functionality). Consequently, the integration into the NPD process and the product architecture of customer feedback becomes a factor in the measure of eventual product quality. Critically, high quality products are a function of:

- greater investment in product architecture – flexible architecture is expensive as it may harbour considerable redundancy;

- experimentation throughout the project;
- experience at module and system levels measured in terms of number of projects each team member has been involved in previously (this aids experimentation).

NPD process stretches far beyond the project, however. Cormican and O'Sullivan's make the link with product innovation management (Cormican et al., 2004). They identify a portfolio management approach to deliver ongoing success. Portfolio management facilitates product screening (developing the right products), inter-project learning and ensuring strategic focus (aligning product development and wider business factors such as markets and macro economic factors). Other critical factors include decentralisation (organic structure), enhancing communities of practice (Lave et al., 1991), and the development of new performance indicators (e.g. team level, knowledge transfer, idea generation, external links and communication, etc.).

4.3 MEASURING IMPROVEMENTS

Managing the development process includes assessing performance. Three indicators are used by organisations to assess the development process: time taken to move through the process to the market launch; cost of the project or actual costs compared to the estimated costs; and effect the development process has on production quality. All three measures have a profound impact on product profitability. However, underlying all of these measures is a host of 'meta measures'; for example, in measuring development lead time, practitioners are likely to consider the time through each milestone, numbers of personnel involved, materials utilised, prototypes, etc.).

4.4 ORGANISATIONAL LEARNING AND IMPROVEMENT CAPABILITIES

Improvement capabilities include the skills and routines that can effect change. They can include technological capabilities that improve the embedded technology and skill base. More times than not, however, these capabilities will rest with organisational skills and routines. These competencies draw on different learning sources such as past experiences and current project implementation insights. Improvement capabilities are the mechanisms an organisation uses to externalise individual learning, i.e. directed, managed efforts to enrich the organisation's developmental assets.

5. THE DILEMMA OF EXPLOITATION VIS-A-VIS EXPLORATION

Benner and Tushman (Benner et al., 2002; Benner et al., 2003) present a challenging thesis for students of process improvement. Essentially they argue that process improvement arising out of TQM, Six Sigma or other approaches, will inhibit radical product innovation but support incremental product innovation. In other words, process improvement is of short-term benefit to businesses in that it enhances the exploitation activities of businesses; for example, squeezing more value out of existing platforms and technologies. However, process improvement inhibits exploration (radical innovation) and hence longer-term viability of the business. Benner and Tushman call on businesses to become ambidextrous – do exploitation *and* exploration simultaneously – and for senior managers to be strategic in reconciling the 'productivity' paradox posed by process improvement methodologies and (longer term) outcomes.

5.1 IMPLICATIONS FOR CI IN NPD

Benner and Tushman's rather unnerving findings fundamentally challenge existing business improvement frameworks in the context of new product development and exploration. Whilst TQM is entering a 'post-modern', 'emancipatory' phase (McAdam et al., 2004), its top-down control focus restricts the ability of practitioners to embrace exploration and to gain competitive advantage through innovation. For the lean method, taking waste out of a business may well expel the necessary redundancy for experimentation and exploration. Moreover, the quest for standardisation, modularisation and design for manufacturability (Panizzolo, 1998) contradicts some of the fundamentals of exploration, particularly where high value products are concerned. Moreover, where lean employs multi-functional teams, if the lean philosophy informs and determines behaviour, the scope for innovative radical thinking is going to be restricted because it is liable to introduce waste through uncertainty.

CI, we argue, is not undermined. However, it may be necessary to work the concept harder where it is deployed to secure exploration in product development. Taking a step back, exploitation lends itself well to formal systems of business activity defined in terms of procedure and process. Incremental improvement to these procedures and processes are an integral part of these formal systems. By contrast, exploration is difficult, particularly for SMEs, to formalise as it involves considerable uncertainty and experimentation that is difficult to codify and quantify.

In a setting of exploration, CI displays three main facilitating components. First, is the application of quality/improvement tools to process and procedure. These tools are familiar to all practitioners, though their effectiveness is determined by the second element; namely, the skills and competences associated with their application in any particular setting. The third, critical and unique element is organisational culture.

As discussed earlier, CI is a bottom-up phenomenon. Whilst it needs to be supported by managers at all levels, the improvement initiative has to come from those intimately involved in business functions at spatial and temporal levels (the two key dimensions for process improvement), and seen through to implementation. For example, those working and managing the design space, clean rooms, workshops and laboratories.

CI capability is a function of CI maturity. CI maturity tends to be measured against a number of indicators including the extent to which people and groups initiate and carry through their CI activities; links with strategic goals; and degree of integration with other systems within a business or organisation.

There are examples, however, of radical innovation arising out of organisations that have not explicitly endorsed exploration. Take the case of R&D bootlegging. Bootlegging demonstrates – in some organisations – that there is a cultural and creative disposition to explore new product, material and process ideas, sometimes explicitly against management instruction.

This cultural bent is evident elsewhere. Spencer (Spencer, 1994) and McAdam (McAdam, 2004) as discussed above, both present their normative case for cultural determinants of TQM success. Both authors attempt to transcend TQM's functionalism. Spencer argues this functionalism is only true if one sees TQM as exclusively a set of procedures or tools rather than as a philosophy of cultural change. Spencer's cultural model rightly does not reject TQM's functionalism, but does suggest that within it there is room for an interpretive component similar to McAdam's social constructivist model. The question remains, why try to make TQM something that it is not? It may just be a

limited and practical concept. Its failure arises not out of its functionalist ontology, but rather that it is the wrong concept to apply universally across a business, and particularly to creative functions within a business.

Let us apply CI, then, to the concept of bootlegging – an extreme case of creativity and radical new product and process development. Bootlegging is an exemplary case of CI in which individuals shift resources towards exploration in order to generate new ideas and/or build capability for future exploitation. The autonomy of creative people enables them to work clandestinely for the good of the business (bootlegged innovations tend to stay within the firm) in the longer term. In the absence of bootlegging, from a top down perspective, the failure of senior management to resource explorative work might conceivably result in the firm going out of business. Moreover, bootleggers are by definition attuned to organisational objectives and engage in boundary spanning and inter-firm networking. And, paradoxically, they at some point transfer their learning to the organisation (and hence other teams).

None of this is to suggest that applying CI to NPD is easy in the formal as opposed to the informal sense (seen in bootlegging which works because improvement is embedded in the cultural mindset or practitioners). Part of the problem is witnessed by Taylor and Pearson (Taylor et al., 1994) when they note that:

> Another reason is that the central tenets of the established programmes, such as "fitness for use", "conformance to requirements", "right first time", cause much argument when used to evaluate R&D "products". In particular the definition of "defect" in R&D is controversial. (p. 3)

Clearly, a number of these concepts are inappropriate for NPD organisations. The generation of metrics that can be used in NPD is labour intensive. And because NPD activities are so far removed from productivity, output and turnover measures, they are more often than not avoided. Moreover, the discussion about the definitions of metrics is problematic, not least because such measures can align cause with a particular individual or group, and hence initiate unwelcome blame and critical comment. However, such metrics as the number of ideas generated, presentation of comprehensiveness (through decision trees), involvement of different functions in the process, and others should not threaten those involved in NPD.

However, the application of CI in NPD organisations has the potential to dwarf the financial benefits attributed to improvement activities further upstream. With degrees of autonomy over the creative process so much greater, and the ability to own process and hence improve it is significant at a number of levels. Obviously in the age of many firms' dependence on new products for revenues – and previous empirical work has endeavoured to examine this – shortening lead times, meeting self-imposed or customer-imposed milestones, are inherently good and have an impact not only on the bottom line, but also in attracting repeat business.

It is much easier for creative personnel to be aware of an organisation's strategic goals and also to use them to inform improvement behaviour. The same is true of other CI indicators such as measuring improvement activity against strategic objectives. Moreover, the link here can be made between strategic objectives and the integration of CI into other formal and informal systems within an organisation such as manufacturing, quality assurance (QA), and indeed bootlegging.

Finally, we return to loops of learning. Double loop learning with its inherent reflexivity (where the direction of view is towards the centre), is a core value and a prerequisite for

improvement, despite and because of its challenge to organizational policies and objectives.

6. CONCLUSION

This paper has argued that the utility of most improvement methodologies in modern business organisations – particularly in the context of the importance of new products on revenues – is limited. The philosophical underpinning of CI, however, has the potential to enable all-important exploration within and between businesses at high levels of maturity. It is necessary now to back this claim up with new empirical research. The link between 'ambidextrousness' and CI capability needs to be investigated. Causality could be in both directions, or indeed they could be mediated by a third factor. Alternatively, examples of ambidextrous organisations could be found with low CI capability. The role of entrepreneurs, for example may be significant.

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