

## **VALIDITY OF BUSINESS STRATEGY AS DRIVER IN TECHNOLOGY MANAGEMENT – A CRITICAL DISCUSSION**

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### **ABSTRACT**

Frameworks for technological development are increasingly requiring that technology must be developed in accordance with the corporate business strategy. It is an interesting tendency that technological development should reflect and interact with central change processes of the enterprise. This is however colliding with challenges in case of normative or prescriptive strategies: Such strategies can be erroneous, misrepresenting, unsubstantiated, short lived, and centered narrowly in internal top-level management processes. This paper discusses advantages, disadvantages and alternatives in connecting technological design tightly to the business strategy. The purpose of this paper is to advance a research agenda, where long-term orientation of technology is connected to the necessary tools for obtaining insight in assessing adequacy, reliability and quality of business strategy and evaluation of alternatives. Alternatives are related to business environments, compliance, infrastructure, knowledge, skills and societal factors.

**Keywords:** Management of technology, business strategy, strategic alignment, maturity of strategy, assessment of strategy

### **INTRODUCTION**

Technology and organisation are closely interrelated and ideally the technological design and development is guided by the needs and requirements of the organisation (Olson et al., 2005). The organisation as well as the technology needs to be governed by long term orientation to ensure the durability of investments and complex technologies (de Wit & Meyer, 2010; Erickson et al., 1990; Grant, 2010; Mintzberg, 2005). The business strategy will typically express the long term orientation of the organization (Kaplan & Norton, 2001; Knights & Morgan, 1991; Mintzberg, 1987). Strategies can be explicit or praxis-driven (implicit). In the following, the focus is on explicit strategies.

Explicit strategies should ideally be developed from multi-factorial decision making processes based on the organisation's capabilities combined with relevant boundary conditions in the form of markets, competitors, legislation, and general circumstances of the society (Shapiro, 1989). Technology should not alone be developed in accordance with the strategy in a one-way, linear process, as strategy will often be influenced by technology as from the opportunities and threats imposed by this on the organization (Luftman et al., 1993; Itami & Numagami, 1992). In the managerial hierarchy it must however be assumed that business strategies will be the primary point

of reference in all subordinate decision-making and design processes (Bakos & Treacy, 1986). Venkatraman (1989) emphasise the concept of fit between strategy and technology.

In the IT-inspired discipline of enterprise architecture, it is mandatory to identify connecting lines between business strategy and the portfolio of technological artefacts (Bernard, 2012; Aitken, 2009). A lot have been written about alignment of strategy and (especially) information technology. Enterprise architecture is specifically seeking the state and expected changes related to operational practices and strategy elements (Parker, 2009). Ross et al. (2003) suggested enterprise architecture as tightly connected to business strategy even in an intrinsically step-wise progressive form. Ross (2005) is however making quite distinctive reservations in this respect and suggests that the progressive form do not need to be progressive but more circumstantial and fluctuant over time. Enterprise architecture can in this sense help to identify technological capabilities that can inspire strategy development processes. When enterprise architecture oppositely should convert given strategy into technology, it will face shortcoming in the event a corporate strategy not sufficiently reflecting the fullest of the organisation. Enterprise architecture might therefore be left with the difficult assignment that the given strategy is insufficient for design of corporate technologies.

This paper is based on the interest of the interaction between technologists and business strategy. The research question is to invigorate an agenda of identification, development and operationalization of principles for technologists to design technology with business strategy as a requirement. The motivation for this is (1) theorists criticising strategies based on rational behavioural economics (Ariely, 2009), (2) apparent absence of critical voices of the momentum to align strategy and technology, (3) the tendency of technological frameworks to include strategic alignment as a critical factor, and (4) the lack of tools for technologists to navigate strategy-requiring frameworks within different types of strategy and related quality of strategy. A fruitful purpose of this paper would be technologists better empowered analytically and diagnostically to enter discussions on the relationship between technology and the driving design criterion.

This paper is based on the assumption that strategy tentatively might not be sufficient as a guiding principle for technological development. Strategies are frequently changed, particularly as reaction to changes in the business surroundings (e.g. financial crisis, war, economic boom), and in the event of change of management (Ariely, 2009). Strategies defined as a result of a management change will often be based on a limited insight in the operating model of the organization (Gallo, 2010), and might furthermore serve as an instrument to position the new management in the organization. Lovally & Sibony (2006) are discussing the quality of strategy and strategic decision making and divide the wrongdoing of this in the notions of distortion and deception. Distortion can be overoptimism, loss aversion and overconfidence. Deception can be wrong time horizons, risk aversion profiles, champion bias, and "sunflower management". Discussions about strategic management of technology are well represented in the literature (Tidd & Bessant, 2010), in this paper is important to view that first comes corporate strategy, then comes the requirements the technology, and lastly comes the strategic management of technological organisation. Bakos & Treacy (1986) are referring to Leavitt's model of the relation between structure and technology; this paper focuses on the case where 'structure' is given and the technology is to follow. The term 'technologist' will be used in this paper for any role of technological management, design, development or operations.

## THEORY

Business strategy, or corporate strategy, is the fabric of verbal and non-verbal interactions in organisations setting the behavioural norms for the organisations long-term orientation (Johnson et al., 2011; de Wit & Meyer, 2010). As such strategy should affect daily actions but only or mostly those related to the organisations expectations of its major activities on a more distant horizon (Porter, 1996). The time frame can be anything from 1 to 20 years. In pharmaceuticals, new drugs take 10 – 15 years to develop and market. In computing gaming consumer attention might change within weeks. The most recognisable form of strategy is the plan (Mintzberg, 1987): “We want to be market leader in 3 years from now.” “We will develop a new generation of X-ray machines that will have 30% of the global market in 5 years.” Mintzberg (1987) add four other fundamental forms of strategy processes: Strategy as a pattern (of behavioural character, verbal or non-verbal); strategy as something differentiated from other actions in the organisation, strategy as position (towards its environment), and strategy as a perspective (how should the organisation think). In Mintzberg et al. (2008), these forms of strategic processes are named prescriptive; descriptive strategic directions include entrepreneur, cognition, learning, power, culture and environment; finally strategy can also be a matter of configuration. Emergent strategies are the processes occurring during the execution of a decided strategy that modifies the given strategy into the actual strategy. Miles & Snow (1978) defined various corporate strategy – technology approaches defined by risk willingness, technological innovation and control/freedom with the main types of Prospector, Defender, Analyzer & Reactor.

Rumelt (1998, 2011) describes a good strategy as cohesive, coordinating, having clear policies, and leads to sound resource allocation. A bad strategy is recognised by incompatible interests. Game theory has originally been a source of inspiration for strategy development (Shapiro, 1989), where the organisation needs to show compliance between actions, resources and the intentions of the opponent. This can also be expressed as a matter of equilibria with a certain given sensitivity. Shapiro (1989) is furthermore making up an image of strategy as a form of organisation aimed at the interrelation between physical capital, intangible assets, control of information, split/merge of organisational structures, networks, standardisation, and make-buy decisions.

Critical behavioural economics described how human decision making is “*emotional, myopic, and easily confused and distracted*” (Ariely, 2009). Motives like cheating and revenge are also not uncommon. In their seminal contribution, Flyvbjerg et al. (2003) talk about “strategic misrepresentation” and “optimism bias” in relation to decision making in large (strategic) engineering projects. Not as bad will, but more as human nature and embedded in organizational behaviour.

Commonly found forms of strategy development is criticised by Barrows (2009) who point to four general mistakes: (1) Lack of profound analysis. (2) Belief in rapid development processes (one day!). (3) Lack of adherence between strategy planning and execution/implementation of the strategy. (4) Dodging of strategy review meetings. The message is that thorough preparation, strong coherence and systematic reviews are needed to ensure the quality of the strategy. Similarly, Campbell & Alexander (1996) points out that development of strategy is more shaped by external perspectives than internal insight, capacity and capability.

What to do, if someone has a sense of the strategy is wrong and even harmful? Gallo (2010) proposes a process of diagnosis, reflection and communication, where problems are identified and supported with factual evidence for change and adaptation of the strategy. Criticism of strategy is difficult (Knights & Morgen, 1991), as it is commonly seen as a criticism of the top level management and a challenged to the power of this. As such strategy is subjective to the management, where subordinates must follow or leave. Further, strategy can be an object of managerial fascination where a lock-in of the employees to the strategy is a symbol or purpose of its own.

Behavioural economics is also the point of departure for Roxburgh (2003) who points out a number of critical issues in strategy development, such as overconfidence, “mental accounting”, “status quo bias”, “herding the flock”, false consensus, “misestimation of future hedonic states. It is suggested to overcome this by taking up more “unemotional” assessments of decisions, promote a culture of challenge, ensure checks and balances, challenge hypotheses, and a general more request of critical discussions. Lovallo & Sibony (2006) introduce their thoughts by stating “organisations are vulnerable to misrepresentations, bias, and simple old lies, but no hopelessly vulnerable”. It is followed by Puranam (2014), in identifying weaknesses in strategy development processes, but also suggesting that implementation of strategies are lagging behind formulation of strategies, and the good implementation will pay itself strongly back.

Most strategies need support by technology, and many strategies are developed from some technological changes and needs (Højmoose et al., 2013; Bakos & Treacy, 1986). In this paper, the main focus is on technology leading to strategy. Baets (1992) discusses that many (information) technology projects are insufficiently aligned with the corporate strategy, but managers likewise do have problems in precisely to explain the actual meaning of the strategy (Galliers & Currie, 2011). It is proposed to develop separate a (information) technology strategy that from time to time is correlated with the corporate strategy. A model perspective emphasising the relationship between external factors and the generalised internal portfolio of resources is presented by Meskendahl (2010).

In many technological disciplines, it has become fundamental to identify and follow corporate strategy (Bernard, 2012; Nollet et al., 2005). Alignment has become a mantra. These technological constructs are often technology-dedicated strategies themselves. Buying commodities for next year is long term but not corporate strategy although it might be supply chain strategy. Sorting of waste is more an operational remedy than a ‘sustainability strategy’ (). Corporate strategy is more holistic and should combine the broadest range of issues within and outside of the organisation. Technologies and technological frameworks demanding corporate strategy can be:

- Quality management, ISO9000, ISO14000, ISO18000, “ISO” 16949 (Prajogo, 2011)
- Enterprise Architecture (Bernard, 2012)
- IT strategy (Luftman et al., 1993)
- Master Data Management (Dayton, 2007; Otto & Ofner, 2011)
- Knowledge management strategi, IPR strategi (López-Nicolás & Meroño-Cerdán, 2011)
- Innovation (Zahra and Covin, 1993)
- EFQM (European Federation for Quality Management) (Wongrassamee et al., 2003)

- SCOR (Supply Chain Operations Reference (Model)) (Zhou et al., 2011)
- Information security (Da Veiga & Eloff, 2010; Fibikova & Mueller, 2012)

Although the theory presented is quite strongly oriented toward information technology, it does not rule out any other technology with strategic relationships. Just to mention: Building design, mechanical design, light sources, combustion engines.

The theoretical presentation above is suggesting business strategy and technology as a dichotomous relationship characterised by a claimed interrelationships, but occasionally also construed as a unidirectional relationship with strategy as determinant. It is important to hold this perspective in the remainder of this paper. This is also in line with the presented views upon quality of the business strategy.

## **METHOD**

The methodology in applied in this paper is qualitative and consists of a literature review and some (smaller) exemplary cases (Klein & Myers 1999). This paper raises some methodological issues and reservations:

1. Business strategy is a hard established dogma of modern management that is hard to challenge.
2. Business strategy is complex and diverse at only the “top level” strategy (plan) is here the departing point although several “hidden” strategic processes might exist in the organisation.
3. Much of the seminal literature is between 20 and 30 years old requiring careful evaluation that the positions are still valid.
4. So far there seems to be a lack of quantitative surveys testing and checking business strategies for e.g. lifetime, misalignment, the CEO’s role, vulnerability and sincerity.

The studies behind this paper come out of the scientifically-based interest to obtain a better and deeper understanding of technological development projects and the business/corporate strategy. The methodology is inspired of the interpretive and social thinking adopting a position like Mathiassen and Nielsen (2008), Lee (1989) and Walsham (1995). A critical observation is used in the studies of the perception of new technology as problem solver (Grant et al 2006, Davis et al. 2009), and the limitations of “traditional” distinctive research versus a broader understanding (Doucet et al 2009).

The cases are compiled from 2012 to 2014 using qualitative interviews, technological inventories and reviews, open and closed sources of strategy announcements, and proposal for technological changes (requirement specifications). The cases are to a certain degree heterogeneous (Pettigrew et al. 2001), but they are neither extreme nor polar types.

It is based on the information system tradition of observing and understanding technological development within its context in organisation, application and business (Mathiassen and Nielsen 2008, Kock 2007). MOT is viewed as concurrent paradigmatic approach each affecting the study objects of the organizational context at both management and operational levels (Schultz & Hatch 1996).

The rationale of business strategies is that they form the upper level of the management structure and are as such not to be disputed or contended. It is therefore difficult to open a discussion of “what if the strategy is insufficient”. This paper is not claiming the strategy should be ignored or circumvented, but is opening a discussion of how technologists should interact with business strategies. Both act independently in the professional judgements of the quality of given strategies, but also contribute to improvements of strategy deficiencies.

## RESEARCH CASES

This paper will address the methodological issues but is as such sticking to the qualitative approach.

Case A. A large trading house, BCorp, were selling products to department stores and own concept stores. In 2006 BCorp was implementing a B2B webshop. The chief designer of the software solution called BCorps head of development and asked if the webshop should also serve B2C customers. The CEO was asked about the design suggestion and replied: We are never going to sell directly to the consumers over the internet; it is simply not our strategy. The B2B shop was launched and did rapidly get a turnover of 10 million EUR per month. Six months later, came the owner of a bankrupted B2C webshop around and offered the whole software infrastructure to the CEO for free. The CEO accepted and a separate B2C webshop was launched with modest sharing of the same IT resources. During 2013, BCorp had been one of Europes main online marketeers. Not through its own webshops but by acquisitions and as a vendor to leading online resellers. The strategy then needed to be revised to re-integrate the two split webshops in to one common pool of information and supply chain resources. The 2006 incident highlighted a strategic decision as driver for a technological design. The design and the subsequent management of technology created a commercial and technological stronger and stronger divide in the company that first 7 years later was recognized as a problem that would take yet 1 – 2 years to fix. The 2006 incident also shows that the strategy was weak and subject to abrupt change, actually more short-lived idiosyncrasies of the top management.

Case B. A digital services provider, TCorp, had for years had several shifts in strategy. Around 2000, the company wanted to be a transnational leader. In 2005, the company should be a regional leader. Around 2012 the existing strategy of a narrow, but dominant market focus was decided. Meanwhile are consumers of digital services becoming less faithfull and abandon TCorp in great numbers. Yet a new strategy is focused at having more and more costs made variable meaning outsourcing of main business functions. From the early strategies, a lot of legacy software platforms were inherited. Some of the first strategies also anticipated a large integrated IT system for customer service and technical operations. Three main software consultancies started on this work more or less correlated with each strategy shift. Due to the extent of the software development process and due to the slowly failing strategies none of the software projects succeeded. TCorp was expected to have lost 300 million EUR on failed IT projects. In the newest strategy, the burden of legacy systems is somewhat realized, but actions to change are not possible due to financial constraints. Instead a smaller project has been started, where a database for sharing of the most critical customer and technical data independent of the legacy systems that then in turn should be set up to exchange data with the central database. The strategies of TCorp have changed faster than the technologies could adapt to. At each period of fixed strategy, this has been driving the software design. In later

stages of the strategy and a strategic renewal, the technology has then been inherently misaligned with the strategy.

In Tambo & Bækgaard (2013) and Bækgaard et al. (2014) are a number of cases presented highlighting the lack of adherence between strategy and technology. The point of departure is that if technology is wrongly designed, outdated, inadequate, or over-controlling, then strong users in the operational organisation might themselves take the initiative and create technology on their own. In an example from a home interior manufacturer, loading of trucks were insufficiently supported with the strategically aligned technology. Instead a forklift driver with slight knowledge of programming made some software useful for the purpose. In a case from an electronics manufacturer, the management supported an expensive ERP system that persistently failed to be delivered. Also it did not support test processes at the production line. The operational associates developed tools in their own without getting permission and by merely bypassing the chosen strategy. This behaviour is named feral systems or shadow systems. This should be viewed along with shadow strategies that can establish the long term orientation in the operational organization especially in cases where the overall corporate strategy is disjoint from “shopfloor” practices.

## DISCUSSION

The very most business strategies are undoubtedly incited by technological changes. The theories of technological determinism (Bimber, 1990) are classical and it seems obvious that technological opportunities, capabilities and innovation will impact strategy development processes at the corporate level. What is interesting in the context of this paper is the conversion from the given strategy to actual technological design, development, implementation, investments or change. This is illustrated below.

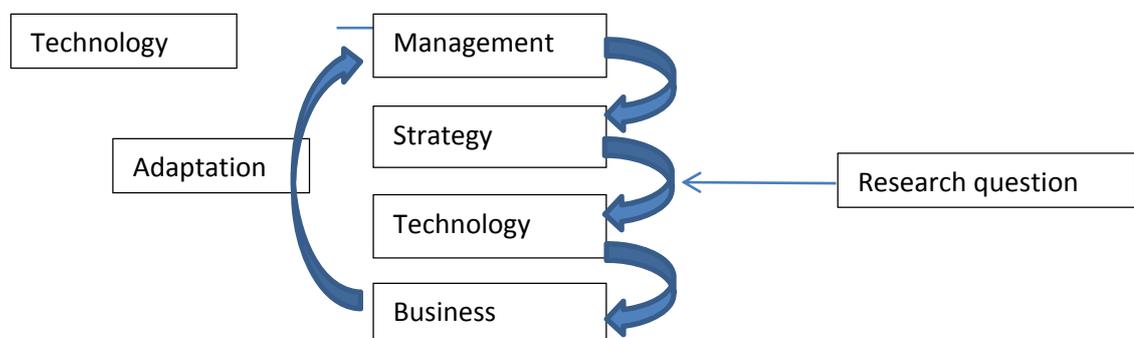


Figure 1. The strategy-to-technology connection

Given the theoretical perspectives brought forward above, strategies can be farther or closer to the actual operating model. Lack of operational insight can “preserve” strategy together with the top management and fail organisational implementation. Strategies can also be conservative and overlook forthcoming changes. In the former case, the operational organisation is left to continue on working within the existing operational with informal necessary adjustments. In the latter case, the operational organisation is again left to circumvent the discrepancy between strategy and actual circumstances. Parts of this can be related to time and necessary “synchronisation” between environmental preconditions and the operational frameworks given. Other parts would be related to

management styles and the ability of the management to understand operational realities, capabilities and challenges and at the same time exercise “visionary realism”.

Case A is reflecting an expanding market and marked by a desire to promote a visionary strategy bypassing the operational organisation. Doubt in the operational organisations abilities can in this way lead management to create new organisational entities that can support specific strategies leaving the original organisation in a paradoxical and critical situation. The case showed that strategy changed over time and technology had to be adapted accordingly. The case is indicating scepticism from all sides as a contributing factor for strategy development.

Case B is more defensive and reflect a contracting market. Although strategies do hold for 4 – 5 years, it looks wasteful that expensive technological initiatives repeatedly are bypassed by strategy changes that render the technology obsolete or at least erode the original strategic alignment. To insist that strategies should hold for longer than it takes to develop technology might hold in some industries: Pharma, physical infrastructure, electricity production. In other industries, technological design must reflect expected strategy lifetime. Technology taking 5 years to develop will never succeed in an industry where strategy changes after 2.5 years. This is again raising an issue of time and synchronisation between strategy and technology with a fair margin.

The cases show that both technology needs to look to other places to obtain rightful adaptation to the companies contexts of relevance. The cases are furthermore showing that strategy is a commonly used point-of-departure for technological design with or without knowledge of misfit with the organisational practice.

The considerations above are leading to a set of findings and points of discussion. (1) Alignment. The technologists should be able to convert sound strategic elements the technological design. (2) Quality assessment. In facing a corporate strategy, the technologist should be able to judge amount elements of high and low quality especially given the relationship between strategy and the operational practice. (3) Alternatives. The technologist should be able to identify, propose, evaluate and promote alternatives to corporate strategic elements. (4) Technology as driver. Technology strategies supporting or contradicting business strategy should be brought up for discussion.

**Quality assessment.** As stated above, the technologist has a certain degree of obligation to reflect upon quality assessing the corporate strategy. Hereby, the suggested environment of critical discussions must be reviewed: Are there any possibilities to positively discuss strategy. TCorp has been publicly traded and strategic changes is among others expected by the markets, strategies are likely to be more short-lived and more quickly developed; BCorp is privately held and strategy statements are not communicated publicly. The quality in the strategy can from the cases thus be based on the depth of evidence and the complementarity with the operational model; with TCorp, strategy development has persistent been abandoning existing operational models and introduced new; in BCorp the operational model hasn't changed for years although the given technology is introducing new sales channels. Negative attitudes in discussing the strategy quality assessments might be included in the overall risk assessment of the given technological initiative. The time issue and synchronisation is evident in this process. Technological design could be based upon assessment of the expected lifespan of the strategy. No worth in doing something that takes two years, if the strategy will hold no longer. Quality issues can relate to the matters stated above about lack of coordinated interests, lack of alignment between strategy and the operational organisation.

**Alignment.** Several references are highlighting strategy – technology alignment (Bernard, 2012; Aitken, 2009; Parker, 2009; Luftman et al., 1993) which assumes abilities for the technologists to receive, interpret, convert, and concretise the meaning and importance of the single elements of the strategy. Alignment has to some degree become a colloquialism, but in the current context, it extends into actual meaning and consequence. The cases are different: In TCorp technology is well aligned in the early phases but grow obsolete before it can mature. In BCorp the market-driven technological trajectory is somewhat stronger than the strategic considerations. BCorp chose strategic alignment as isolated islands at given times, but had to consolidate later on to obtain enduring strategic benefits. Operationally it is possible to simplify this process by creating ‘technology strategy islands’ as above mention for e.g. supply chain management, cybersecurity and social responsibilities that only from time to time are aligned with the corporate strategy. When making changes in corporate strategy this is obviously then to be cascaded into the individual strategies, considering the complexity in such a process.

**Alternatives.** The technologist should be able to identify, propose, evaluate and promote alternatives to corporate strategic elements. With TCorp, alternatives were not strong evaluated which led to strategic failure of the technology; with BCorp, alternatives had some influence, but were implemented as a certain degree of freedom to operate between different styles of operational modes both supported by the basic technology or assemblages of technologies. From Alter (2002) alternative or supporting dimensions are suggested in terms of environment, infrastructure, work practices and customer interaction. Inspired by the descriptive strategies, also issues of skills, culture, entrepreneurial spirit, customer/supplier interactions, could be brought in to the technological design. Ross (2005) suggests is this a matter to focus on operating models, by selecting one and make that persistent, assuming that this is how things mostly should work, potentially resolving conflicts by having different operating models at different organisational levels. Ciborra et al. (2000) are further bringing in potential alternatives such as bricolage (do things by simple means), hospitality (willingness to adopt technology) and improvisation (make things work under various circumstances).

**Technology as driver.** Even if this discussion is related to the technology derived from strategy, the opposite process might prove as a potential differentiator and the literature is rich in this area, worthwhile discussing is however mixed scenarios. In mixed scenarios, technology might influence corporate strategy profoundly, at certain critical points in time, as a constant mutual process, as a “working laboratory”, or wrongly. Issues of technology in the market, competitors adoption, adaptability of generic technologies to the given business processes, development and innovation processes, and similar can also be interesting to observe. In TCorp, various information technologies were depicted as a technology for enabling change, but constituted more a freezing of business processes at a certain given time without providing much new and were not able to deliver before strategies changed. In BCorp, strategy was to some degree influenced by the technological opportunities and projections. So in reverting to the issue of technological determinism, it is worth to discuss, if a certain technological design positively can promote and improve strategy? Or is there a technological threat overlooked in the strategy development process? The common dream for dedicated professionals in the organisation is probably to gain influence at a strategic level on their specific professional dimension of the corporate governance. This leaves a degree of competition and rivalry for attention between technologist and the top level management. The positive side of this is that different technological paradigm can compete on the possibility to impact strategy.

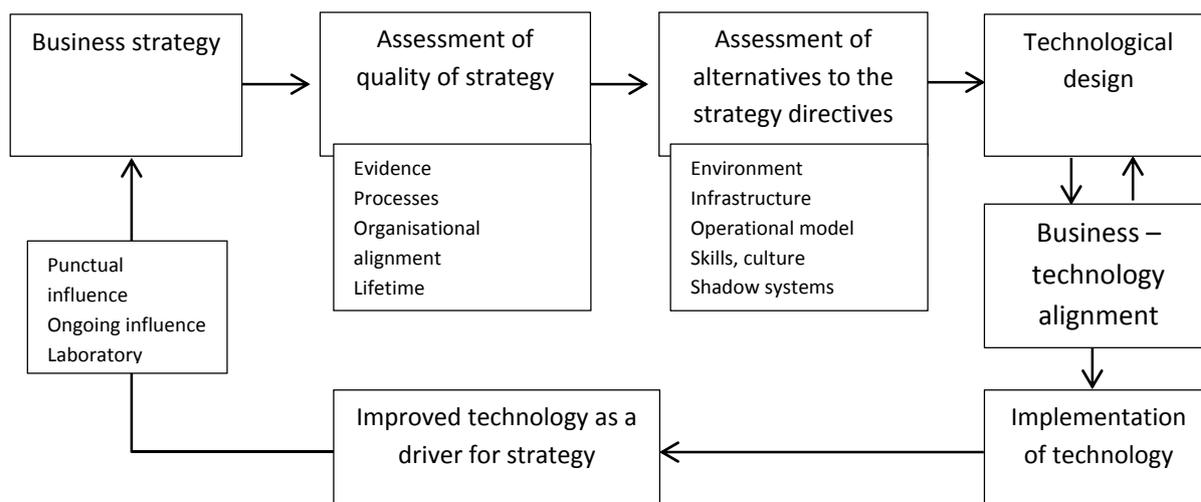


Figure 2. Extended and reflective strategy-to-technology connection

As important directives are that for organisations in focus, the verbal strategy is disputable as driver of technological development without including the business environment and the social and technological infrastructure. The fundamental assets of the enterprise, beyond strategy, are creating a meta-strategic point-of-departure for a more durable and fitting technological design.

Technologists do need design guidelines in identifying long term orientation. In selecting between long term orientation technological design based on “as-is” is as problematic as positioned strategy of short-lived or deceptive kind. The core of technologists’ design orientation is to know the features, capabilities, prerequisites and limitations to the work.

## CONCLUSIONS

Technology and strategy are tightly related and many technological frameworks are pushing forward to pursue direct connections between management of technology and business strategy. This paper has presented the technology – strategy from the viewpoint of strategy as determining for technology. There are plenitudes of studies of how technological changes directly determine strategy. This is external to the company. There are fewer studies taking the internal view of looking at the company-internal processes to determine this relationship. In the company internal context it is expected that technologist are confronted with strategy expression of a great variety of quality. The theoretical contributions to this paper have shed light on both symptoms and tentative cures for quality improvement in corporate strategy.

As suggestions for further work, there are two major strands to follow: Firstly, a number of technical frameworks claim to be able to structure and “code” strategy and strategy implications, e.g. OMG-BMM, BPMN, TOGAF, it could be beneficial to review more in-depth on actual effect of these frameworks. Secondly, more cases of both high and low quality strategies should be collected to get to a more quantitative approach to quality measurement, quality impact, and (technologist) quality assessment.

This paper is based on the potentially controversial view that business strategy is insufficient or lacking quality for technological design. To some it’s an old story. To others it’s a regular challenge to improve our common understanding of the strategy – technology interrelationship. This paper

suggests a technological view on quality assessment of corporate strategy, investigations of alternatives, linking technological alignment to quality and alternatives, and systematic review of technological influence of technological change and opportunity.

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