Exploring requisites and antecedents of continuous innovation

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Abstract

When innovating, an organization needs to be capable of (1) exploring problem definition spaces and (2) exploiting them. The processes in which both activities unfold, display paradoxical characteristics which can be addressed by adopting ambidextrous organizational forms. Analyzing underlying value dynamics indicate that such forms will only be sustainable to the extent that cross-fertilization between both types of activity is achieved. These findings underscore the relevancy of interface management practices directed towards enacting synergies.

Introduction

‘*A system – any system, economic or other – that at every given point of time fully utilizes its possibilities to the best advantage may yet in the long run be inferior to a system that does so at no given point of time, because the latter’s failure to do so may be a condition for the level or speed of long-run performance*’ (J. Schumpeter, The process of Creative Destruction, p.83).

Innovation has long been acknowledged as crucial for the long term survival and growth of the firm; at the same time technological innovation can be seen as one of the critical driving forces behind elevating the economic well-being of people and nations (Schumpeter, 1934; Tushman, Anderson & O’Reilly, 1997). However, organizing for innovation does not present itself as a straightforward exercise (Van de Ven, et al. 1989). The complexities entailed when designing and implementing a sound innovation strategy can be directly related to the multitude of objectives comprised in such a strategy. The notions of incremental versus radical innovation (Dosi, 1982; McDermott and O’Connor, 2002), innovation as continuous improvement through learning by doing versus innovation as creative destruction (Arrow, 1962; Solow, 1997; Abernathy and Utterback, 1978; Anderson and Tushman, 1991; Bower and Christensen, 1995), flexibility to keep innovation options open versus commitment to well-defined innovation pathways (Ghemawat, 1991), divergent versus convergent behavior (Van de Ven et al.,1999), exploitation versus exploration (March, 1991) or path creation versus path dependence (Garud and Karnoe, 2001), are at the core of the dualities being outlined.

As such, organizations trying to achieve both types of activities are being confronted with multiple, often contradictory demands imposing upon organizations the challenge of reconciling paradoxical requirements (Leonard-Barton, 1992, Dougherty, 1996, Benner & Tushman, 2003).

Within the next section we further illuminate the dynamics underlying the multitude of innovation objectives and their implications for organizing the variety of innovation activities implied. This will bring us to the ideas on organizing by means of semi- or quasi-structures (Schoonhoven & Jellinek, 1990; Brown & Eisenhardt, 1997) and ambidextrous organizational forms (Tushman M., Anderson P. and O’Reilly C., 1997, Benner & Tushman, 2003; O’Reilly & Tushman, 2004). At the same time, it can be noted that ambidexterity implies the simultaneous presence of different activities, coinciding with differences in technology and market maturation. Financial returns will inevitably reflect this diversified allocation pattern, leading to the observation that such firms might be ‘inferior’ – in terms of value creation - to focused firms who concentrate on the most lucrative part of the technology life cycle. This then becomes the central point we want to address within this contribution: which are the prerequisites and conditions under which diversified firms of an ambidextrous nature are sustainable?

We will address this question by developing a formal value creation model. This model relates value creation to technology and market maturity, while at the same time cost and benefits for ambidextrous firms are modelled in a formal way. Approaching the dynamics at play in such an analytical way clarifies the impact of antecedents on value creation which is seen as the most relevant criterion to assess sustainability. We will conclude this contribution by discussing the managerial implications of the results obtained and by outlining some issues for further research.

The dual nature of innovation

The challenges organizations face when simultaneously striving to achieve innovation of a more incremental and radical nature, can be traced back to the social dynamics in which both types of activities – i.e. exploration and exploitation – unfold. Indeed, within the extant literature on organizing and managing innovation activities, the multiple roles of communication and interaction have been focal points of attention. The seminal study of Pelz and Andrews on scientists and engineers concluded in the late 1960s with respect to communication: 'the more the better' (Pelz and Andrews, 1967; p 52). Likewise, the influential work of Thomas Allen (1977) underscored the importance of communication in relation to effectiveness within innovative environments. Interaction turns out to be of major importance when designing and implementing suitable problem definition and problem solving strategies. Those findings have been further corroborated and refined by numerous studies addressing the importance and the role of communication within R&D and innovation settings. Important contributions include – amongst others – the work of Allen (1966, 1977), Tushman (1977, 1978a,b), Tushman and Katz (1980), Katz and Allen (1986), Ring and Van de Ven (1989), Angle (1989) and Ancona and Caldwell (1992a,b). The influential work of Nonaka, and Takeuchi again emphasizes the crucial and central role interaction and collaboration play in the context of knowledge creation processes (Nonaka 1990; Nonaka 1994; Nonaka and Takeuchi 1995). Likewise, the overview on new product development processes developed by Brown and Eisenhardt (1995) assigns a central role to communication and interaction, irrespective of the research perspective considered.

However, some of the findings originating from this research stream indicate that the role and impact of communication and interaction is not without its particularities. Allen (1977) advanced the notion of gatekeepers in order to explain why more communication with external partners did not always translate into better performance. Dougherty (1992) argued that the presence of 'interpretive barriers' can be seen as one of the main difficulties cross-functional R&D teams face. Sub-optimal performance results from not being able to transcend such differences. Ancona and Caldwell (1992a) were confronted with puzzling relationships between communication patterns, team composition and the performance of R&D teams. Likewise Fiol (1994) and more recently Keller (2001) have pointed out that functional diversity is beneficial for technical quality but is at the same time associated with diminishing levels of group cohesiveness.

These puzzling findings can be better understood by acknowledging the dual role interaction can – and should – play in relation to knowledge creation, a phenomenon present in any innovative trajectory. This dual role can be related to the distinction made by March (1991) between exploitation and exploration. Whereas exploitation refers to activities such as 'refinement, efficiency, selection and implementation', exploration is best captured by notions like 'search, variation, experimentation and discovery' (March, o.c.,p.102). Strong similarities can be noticed with the notions of divergent and convergent behaviour as outlined by Van de Ven, Polley, Garud and Venkatraman (1999). The social dynamics in which both types of activities are embedded not only expose characteristics of a different, but even of a paradoxical nature. Exploitation benefits from homogeneity, whereas exploration presupposes heterogeneity; exploitation thrives on consensus and can be seen as identity confirming, while exploration implies conflict and a redefinition of identities.

The dual and paradoxical nature of innovation

Exploitation. Joint and integrated efforts are needed in order to fill in the 'missing bits, bytes and links' of information during processes of knowledge creation. As Pelz and Andrews already remarked: 'frequent contacts and interaction are beneficial when it comes to solving problems by adding pieces to the puzzle or by detecting errors one overlooks because of being too engrossed with the problem at hand'. (o.c. p.52). Faced with (difficult) problems, people start to work and to discuss with each another. This behaviour generates an inherently social process that results in and benefits from interaction. In a more technical sense, one might state that interaction is instrumental in handling uncertainty. In line with the work of Schrader, Riggs and Smith (1993), we use a definition of uncertainty as 'a characteristic of a situation in which the problem solver considers the structure of the problem (including the set of relevant variables) as given but is dissatisfied with his or her knowledge of the values of these variables'. As R&D professionals and their teams are continuously confronted with situations characterised by high levels of uncertainty, the ability to involve knowledgeable colleagues in this endeavour is beneficial for the innovation processes. This has been abundantly illustrated by numerous scholars (see for instance Allen, 1977; Tushman and Katz, 1980; Tushman, 1978; Van de Ven et al., 1989; Brown and Eisenhardt, 1995; Orr, 1996; Brown and Duguid, 1991, 2000).

Exploration. However, joint activity does not limit itself to filling in 'missing bits, bytes and links'. New product development processes aim at creating novel products, processes and/or services. Here too, interaction plays a major role. As pointed out by Pelz and Andrews, contacts can be useful to provide intellectual stimulation and hence to generate new ideas: 'jostling a man out of his old ways of thinking about things' (o.c., p. 52 & 53). Schön (1963) drew our attention to the fact that novel solutions and insights stem from problem-defining and problem-solving interaction sequences, whereby multiple opinions and viewpoints become integrated into a new synthesis or artifact. Likewise, work within the domain of sociology of science and technology points to the social dynamics in which the developmental processes of new scientific knowledge and/or technological artifacts are embedded, including their conflicting nature (Fleck, 1934; Kuhn, 1962; Mulkay, 1968; Ben-David and Collins 1966; Bijker, 1996) Interaction during new product development processes thus implies generating and addressing the differences in opinion and interpretation between the actors involved and their translation into a novel synthesis. Stated otherwise, interaction is not only instrumental for reducing uncertainty but for handling ambiguity as well. Ambiguity implies an unclear situation with respect to the problem-definition and hence problem-solving space considered as relevant by the actors involved. In more formal terms, ambiguity relates to ‘the need for determination at the level of the relationships between the variables and the problem-solving algorithm (level one) or even at the level of the relevant variables (level two)’ (Schrader, Riggs and Smith, 1993). Dealing with ambiguity ideally results in the genesis of a novel synthesis whereby the variety of ideas that prevail among a variety of involved actors are re-interpreted, re-negotiated and finally fused. In other words, handling ambiguity implies acknowledging and addressing differences in opinion about what might hold true or what might be relevant to consider or to integrate during certain development trajectories. As a consequence, ambiguity extends beyond the idea of information exchange in order to fill in gaps present in an existing framework; it relates directly to the creation of new frameworks or knowledge. Actors belonging to different communities are confronted with finding ways to handle a variety of beliefs, evaluation routines and enabling artifacts. In March’s terms, exploration as well as exploitation is – or should – be an intrinsic part of any truly innovative effort and is needed for any system in order to survive (March 1991).

At the same time, it can be noted that both activities display (social) characteristics of an opposite nature. Within innovative settings, this phenomenon has been highlighted by the seminal study of Katz and Allen (1982) on the ‘Not Invented Here’ syndrome. Katz and Allen examined the relationship between average project member tenure and performance. The results of this classical study are well known: an initial increase in performance is followed by a strong decline after a period of three years during which project members have worked together. The initial growth in performance can be related to an improvement in cohesive working relationships and team building. However, developing better or more cohesive working relationships – based on a better appreciation of skills and capabilities – results in patterns and routines that ‘exhaust’ diversity over time. This phenomenon was raised by Festinger almost half a century ago: ‘The more cohesive the group, that is the more friendship ties there are within the group and the more active the process of communication which goes on in the group, the greater will be the effect of the process of communication in producing uniformity of attitudes, opinions and behavior’ (Festinger et al., 1960; p. 175). Katz (1997) pointed out that groups working together over longer time frames might evolve from healthy levels of self-reliance towards problematic levels of closed-mindedness whereby novel situations and approached are either ignored or forced into known categories. A pattern of increasing isolation sets in characterized by selective exposure; group members tend to communicate only with those whose ideas and outlooks are in accord with own interests, needs and attitudes.

Similar phenomena have been amply documented within the innovation literature (see for instance, Stork, 1991; Moenaert & Souder, 1996; Moenaert & Caldries, 1996) as well as within the literature focusing on team effectiveness (for an overview based on team formation and effectiveness, see Bouwen and Fry (1996) and Wheelan and Hochberger (1996)). Likewise contributions related to the notion of trust as a necessary ingredient of collaborative relationships arrive at similar conclusions (e.g., MacAllister (1995), Lewicki and Bunker (1996)). Homogeneity and similarity are found to be crucial antecedents for developing trustworthy relationships. As for innovation projects, this introduces a paradoxical challenge. On the one hand, collaborative relationships are essential for addressing the uncertainty involved in a smooth and efficient way. On the other hand, the homogeneity implied is in sharp contrast with the variety needed to arrive at novel solutions. Stated otherwise, divergent opinions and the conflicts they entail, are crucial for development teams in order to arrive at the creation of novel products and/or services.

The central role of conflict for novelty to arise has been rigorously documented in the field of developmental psychology. Within this field, a range of scholars has been advancing the idea that knowledge creation is intrinsically a socio-cognitive process. Important contributions stem from Vygotsky (1978, 1986) and Luria (1971), while the work of Doise, Mugny and colleagues (1984; 1998) empirically demonstrated the central role of socio-cognitive conflict. Prominent findings relate to the absence of superior models in order for development to happen while at the same time conflict, i.e. the presence and hence the confrontation of different approaches, turns out to be essential to arrive at the integration into a new synthesis: 'If social interaction is of particular importance ….for development, it is to the degree that socio-cognitive conflict arises.…' (Doise and Mugny, 1984, p. 101). Stated otherwise, in order to arrive at novel insights and knowledge, coordination or interaction between individuals is needed and should be characterized by conflict. Such conflict builds on opposing viewpoints and hence presupposes some heterogeneity[i].

Insert Figure 1 around here

Hence, innovation activities, by their very nature, display dual and paradoxical requirements in terms of interaction as table 1 summarizes. The polarities pertaining to the social dynamics in which exploitation versus exploration unfold, can be seen as one of the root causes of the paradoxical nature of innovation strategies firms are being confronted with (Schumpeter, 1939: Abernathy, 1991; Abernathy and Utterback, 1978; Anderson and Tushman, 1991; Ghemawat, 1991; Benner and Tushman, 2003).

So, when designing and implementing innovation strategies, organizations need to find ways to handle those paradoxical requirements. At least this is, if they want to achieve objectives in line with exploration and exploitation simultaneously rather than sequentially.

Handling paradoxical requirements when pursuing exploration and exploitation simultaneously: towards ambidextrous organizations.

Paradoxes can be seen as situations in which contradictory elements operate simultaneously: this simultaneity results in situations in which choosing one side occurs at the expense of the other and vice versa (Hampden-Turner, 1990; Quinn and Cameron, 1988; Janssens and Steyaert, 1999; Lewis, 2000). With respect to coping with paradoxical requirements, several strategies have been proposed (Poole and Van de Ven, 1988; Steyaert and Janssens, 1999). Within these strategies, separation of contradictory elements or activities by means of time and space figure prominently. These principles are to be found as well in the notions of semi- or quasi-structures (Schoonhoven and Jellinek, 1990; Brown and Eisenhardt, 1997) and ambidextrous organizations (Tushman, Anderson and O'Reilly, 1997; Benner and Tushman, 2003) advanced to handle the paradoxical requirements encountered. Christensen and Overdorf (2000) advance the idea of complementing 'traditional' organisational practices, via the creation of new organizational structures, spinouts and acquisitions in order to achieve the exploration oriented objectives of an innovation strategy. To the extent that companies pursue at the same time objectives of a more exploitative nature, hybrid organisational forms will therefore become a necessity. This argument has been advanced explicitly and convincingly by Nadler and Tushman (1997) and Tushman, Anderson and O'Reilly (1997) when elaborating on the idea of ambidextrous organisations (Duncan, 1976). When facing the challenge of embracing incremental, architectural and radical innovation, the authors point to the relevance of designing inherently unstable organizations as the adequate organisational arrangements required for the different objectives are of an opposite nature. Such arrangements are complemented by the presence of a clear common vision within which they make sense. The presence of overarching concepts allows spanning a variety of perspectives and technical competencies, while at the same time having sufficient 'mobilising' power to result in joint action. At the same time, capabilities – at the senior management level – are required to balance the tensions presented[ii].

Within such configurations, conflicting ingredients can co-exist by adopting organizational designs of a hybrid nature. As a consequence, innovation strategies entail the deployment of organizational arrangements of a heterogeneous nature.

As 'hybrid' organizational forms imply the simultaneous presence of different activities - coinciding with differences in technology and market maturation - financial returns inevitably will reflect this diversified resource allocation pattern. Compared to organizations that focus (within a given time period) on the – at that moment – most lucrative part of the portfolio, hybrid organizations may tend to be inferior in terms of financial performance[iii]. In addition, the idea of semi-structures or ambidextrous organizations is diametrically opposed to the notion of internal consistency that has dominated the literature on organizational design over the last decades (Mintzberg, 1979; Miller & Friezen, 1986). Given such tendencies towards internal consistency, ambidextrous organizations imply additional resources as higher levels of managerial and organizational complexity are being introduced, Stated otherwise, hybrid or ambidextrous organizations face the risk, at least in the short term, of being outperformed by organizations with more focus.

Hence the question whether and under which conditions ambidextrous organizations can indeed be sustainable becomes a pertinent one. Within this contribution we want to explore such antecedents and requisites by developing a set of premises that will allow simulating and hence assessing their effects on value creation, as we will explain within the next section.

Methodological Approach: defining a formal value creation model.

In order to clarify the nature of the prerequisites as well as the sustainability - i.e. relative performance when compared to focused firms – of such 'heterogeneous' or 'ambidextrous' organizations, we develop a rather simple set of premises, which will allow to model the value creation efforts of different types of firms.

These premises relate to 1) the technology life cycle affecting the amount of value created in a given time period; 2) the resources needed to organize and manage the diversity entailed within ambidextrous organizations; and finally 3) resources needed to enact the diversity present within such ambidextrous organizational forms (if chosen to do so).

In the next paragraphs we will elaborate the different assumptions and their formal counterparts systematically. Given that certain relationships between constituting variables are of a recursive nature, we will opt in a next step for simulation to explore the issues raised (Law & Kelton,1991). Within the simulation analysis the comparison between 'focused' and 'ambidextrous' firms will be central. With respect to the latter, we will develop and compare several models. This variety coincides with differential emphasis on a) resource allocation patterns across the portfolio of products/technologies; b) efforts devoted to constructive gate-keeping activities or 'coupling' (tight versus loose) and, finally c) the characteristics pertaining to heterogeneity of the (product/technology) portfolio present (technology distance, concentration).

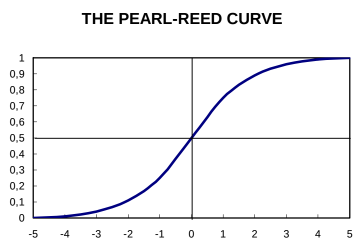
Modelling assumptions

Value creation reflecting technology life cycle positions.

In order to model the value creation of firms, a Pearl-Reed curve is used to reflect differences related to the technological life cycle (Young, 1993, Martino, 1972).

The formula for the Pearl-Reed curve is $\frac{L}{1+e^{-b(t-a)}}$

For L=1, b=1 and a=0, this curve looks as follows:



We distinguish between four different stages within the technology life cycle: seed, growth, mature and decline. Using Rogers' curve on the diffusion of innovation, these are the threshold values for each of these stages:

Lifecycle stage	Threshold values
Seed	From 0.01L to 0.16L
Growth	From 0.16L to 0.84L
Mature	From 0.84L and upwards
Decline	From 0.999L and downwards

Combining these two building blocks, we come to the following model:

$\frac{L}{1+e^{-b(t-a)}}$ for the rising part of the curve

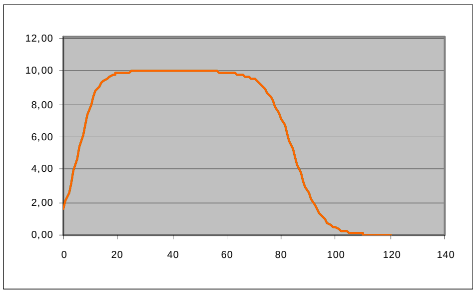
$\frac{L}{1+e^{b'(t-a')}}$ for the sinking part of the curve

Whereby

- L = 10 (arbitrarily chosen)
- ‘a’ is determined by which starting point is chosen
    - if the chosen stage is ‘seed’, ‘a’ takes the value for which the Pearl-Reed curve will be at .1% of its maximum
    - if the chosen stage is ‘growth’, ‘a’ takes the value for which the Pearl-Reed curve will be at .16% of its maximum
    - if the chosen stage is ‘mature’, ‘a’ takes the value for which the Pearl-Reed curve will be at .84% of its maximum
    - if the chosen stage is ‘decline’, ‘a’ takes the value for which the (declining) Pearl-Reed curve will be at 0.99% of its maximum

This approach – whereby a reflects different positions on the technology lifecycle – allows to continue with only b and b’ as parameters within the Pearl-Reed formula in further simulations. These remaining parameters b and b’ reflect the inclination of the curve, for the rising and sinking part of the Pearl-Reed curve respectively. When b increases, the upward part of the curve will become steeper; an increase in b’ results in a sharper decline for the sinking part of the curve.

E.g. starting in the ‘growth’ stage, with b=0.3, decline setting in at t=50 with b’=0.2, the model for value creation looks like the figure below.



The value created during any given time period is obtained by calculating the integral of the curve for the period under consideration and results in formula (1)
(1)

For focused firms, i.e. organizations that allocate 100% of their resources to one activity, the overall value will be the result of the integral outlined. For ambidextrous

$$\int_{a}^{a+40} \frac{L}{1+e^{b(t-a)}}\,dt = \frac{L}{b}\ln\left(\frac{1+e^{-b(40-a)}}{e^{-b40}+e^{-b(40-a)}}\right)$$

firms, the overall value equals the weighted sum of the values obtained by the integral pertaining to the different technological stages outlined (seed, growth, maturity, decline). Weights reflect directly the resources allocated to either activity and are subject to simulation, ranging from 10%/90% to 90%/10% whereby a minimum level of 10% activity is deemed essential to be considered an ambidextrous firm.

Resource considerations/Costs encountered by ambidextrous firms.

As argued above, ambidextrous firms are confronted with additional levels of organizational and managerial complexity (see in this respect Christensen, 1997; Sheremata, 2000). A certain proportion of the added value created over time will be taken into account as cost and hence become deduced from the value total obtained by applying (1). The proportion applied ranges from 4 to 10% depending on the presence of different stages within the portfolio. Seed activities as part of the portfolio are considered as implying more resources (5%) than mature or even declining activities (3%, 2% resp.). Moreover, based on the work of Christensen (1997), it seems plausible to assume a positive, exponential relationship between technological distance – as observed at any given time period between different parts of the organization – and the amount of complexity encountered. Finally, we assumed as well a – curvilinear – relationship between resource allocation patterns across different parts of the organization, and the managerial and organizational costs encountered. This relationship has been incorporated by means of an Herfindahl index, which increases the more resources are equally distributed. This results in the following formulas:

$$c_{div} = f(stages, value\,created) * g(herfindahl) * h_1(techn.dist)$$

$$f(stages, value\,created) =$$

$$(5\% * \sum i_s + 4\% * \sum i_g + 3\% * \sum i_m + 2\% * \sum i_o) * overall\,value\,created\,in\,one\,period$$

- where i_s, i_g, i_m and i_o are binary variables (0/1), indicating whether a 'seed' stage, 'growth', 'mature' or 'decline' is present within the organizational portfolio in this period.

$$Herfindahl\,index = \sum \alpha_i^2$$

$$g(herfindahl) = 1 - (\alpha^2 + (1-\alpha)^2)$$

$$h_1(techn.dist) = e^{\delta\,dist}$$

- 'dist' is either 0 (same stage), 1 (1 stage difference; e.g. seed-growth), 2, or 3,
- δ= .135 (chosen so that at the greatest distance (3), this value is 50% higher than at the smallest distance (0))

Similarly, resources/costs for enactment are modelled with the same building blocks. However, the influence of the technological distance – as observed at any given time period between different parts of the organization – is in this case assumed to be a negative, exponential, relationship, implying that the larger the 'technological' distance the greater the willingness of the different parts of the organization to engage in mutual development. This results in the following formulas:

$$c_{enact} = f(stages, value\,created) * g(herfindahl) * h_2(techn.dist)$$

$h_2(techn.dist) = e^{-\vartheta\, dist}$

- dist is either 0, 1, 2, or 3,
- θ = .231 (chosen so that at the greatest distance (3), this value is 50% lower than at the smallest distance (0)).

Figure 2 summarizes the relationships outlined above.

Insert Figure 2 around here

Results

Table 1 summarizes the findings – in terms of value creation – for focused firms. As expected, differences in terms of position on the technology life cycle translate into differences in terms of overall value creation over one time period consisting of 40 periods, with the mature stage resulting in the overall best performance. Increasing levels of b and b' affects the overall value obtained, especially – and not surprisingly - for early and latter stages (seed and decline). It can also be noticed from table 1 that firms situating their activities within the mature part of the technological life cycle outperform all three other types of (focused) firms for values of b, b' ranging from 0.1 to 0.4. As such, this firm will be used as a 'benchmark' when comparing the performance of focused firms with ambidextrous firms.

Insert Table 2 around here

Within table 2, a comparison between such a focused firm and a ambidextrous firm combining mature activities (90%) with seed-activities can be found. When looking at the first period only, the value differential after one period of 40 episodes becomes apparent (391,29 versus 359,06). As such, these observations are again, a logical consequence of the concepts introduced and their analytical counterparts.

A logical next step consists of comparing focused and ambidextrous firms over longer time periods. Table 2 contains the findings for both the focused firm – starting with 100% of mature activities - and the ambidextrous firm, combining mature activities with seed-activities over three time periods, consisting each of 40 episodes. Given the initial start conditions, in the next periods, the focused firm will evolve towards maturity and decline, while the ambidextrous firm follows a similar thrust. Within this analysis, different levels of b' have been introduced, ranging from 0,1 to 0,4 (higher levels of b' would lead to decline rates similar to fashion items only). At the same time, b has been set at 0.2[iv].

Insert Table 2 around here

As table 2 makes clear, only when b' exceeds 0, 15 ambidextrous firms of this nature outperform focused, mature firms. As such, this difference can be labelled as a 'portfolio effect', which becomes stronger the steeper the decline of the value curve. At this stage, only value creation is considered; when taking into account the additional costs encountered by the ambidextrous firm (see table 3) - stemming from managing and organizing the diversity present - the relative superiority of ambidextrous firms (again, for b’>0, 15) disappears; only when b’ equals 0,4 a marginal difference in favour of ambidextrous firms is observed.

Insert Table 3 around here

Of course, and rightly so, it can be argued that the ambidextrous firm might benefit from more than merely the portfolio effect. Hence, in a next step, two scenarios relating to the degree of resource re-allocation flexibility are being introduced. Within a first scenario this flexibility is unlimited, resulting in a resource allocation pattern yielding the highest total revenue, with the only constraint that at least 10% of the resources are devoted to the ‘less performing’ part of the portfolio. Secondly, a more realistic scenario is being deployed whereby the organization is allowed to re-allocate 5% of its resources per episode from period 2 onwards whereby shifts occur when one part of the portfolio is superior to the other.

When comparing the findings of table 4 with the results obtained for focused firms in table2, the difference between focused and ambidextrous firms becomes more outspoken and in favour of ambidextrous firms. In terms of value creation, we obtain differences ranging from almost 9% to 60% depending again on the level of b’. Bringing in the resource/cost implications of ambidextrous firms does not significantly alter this picture, as Table 5 makes clear. The difference between the two resource allocation scenario’s (‘without constraints’ and ‘gradually’) is marginal in terms of total value creation. Comparing both scenarios in terms of costs encountered, it can be noticed that gradually shifting implies higher costs, an effect due to the presence of the Herfindahl index within the resource equations.

Insert Table 4 & 5 around here

As such, a first important observation becomes prominent; ambidextrous firms might indeed outperform focused firms, but this clearly depends on two conditions or requisites; first the rate of decline of a certain technological regime affects the extent to which ambidextrous firms benefit from the presence of a portfolio of activities. Second, and yielding a far greater effect, the extent to which resources can become re-allocated across different parts of the portfolio affects the value differentials observed. This latter observation points our attention into the direction of the synergetic potential between different technologies, in this case in terms of deployment of resources/assets across different technologies. As will become clear in the next section, the notion of synergetic potential will manifest itself under other forms as well.

Ambidextrous firms enacting synergies between exploitation and exploration

Within the next calculations, we model the effect of enacting the diversity present within ambidextrous firms on value creation. In order to model such relationship, we assume that firms actively pursuing synergies between different parts of their organizations and the technological capabilities they embody are able to influence both b and L. Indeed, as argued above, reasons to pursue this type of ambidextrous firm can – and should - be found in creating additional value which compensates for adopting extended (investment) time frames and for the increase in complexity encountered. To the extent that ambidextrous firms are able to do so, this result in a superior performance compared to ambidextrous firms which do not enact the diversity present.

Table 6 summarizes the findings for two different resource configurations; ambidextrous firms focusing on mature or seed activities (90%) which they complement with seed or mature activities (10%). Within table 6 net value creation is being depicted (i.e. value minus costs encountered) both in absolute terms (upper half) and expressed as a proportion of the value obtained by the most performing focused firm, i.e. a firm which devotes all its resources to mature activities (lower half).

Insert Table 6 around here

As the left side of table 6 makes clear, ambidextrous, enacting, firms are able to outperform – within one given time period consisting of 40 episodes – their focused counterpart, as soon as L increases with more than 10 % (in absolute terms: +1) or when L increases with 10% and b increases with +0,1. Moreover, even a ambidextrous firm with a portfolio characterised by 90% seed and 10% mature activities, turns out to be able to outperform a focused firm within one time period, if L doubles (in absolute terms + 10) and when b increases additionally with 0.2[v].

Finally, when bringing in resource allocation flexibility and three time periods, the findings obtained so far start to reinforce each other leading to much more interesting perspectives for ambidextrous, enacting firms. Table 7 reports the findings obtained in this respect. The net value creation – over three time periods, each consisting of 40 episodes – of an enacting firm, able to re-allocate resources gradually, and starting with 90% of mature activities (combined with 10% of seed activities) outperforms the most performing focused firm in all cases. The lower half of the table indicates the proportional difference with such a focused firm (100% mature activities). A more systematic analysis even reveals that – in the case of no positive effect on L, ambidextrous firms can outperform mature focused firms, if b > 0.05 and the portfolio includes 70% mature activities. When additionally L increases by 1, ambidextrous, enacting firms, starting with a portfolio with 40% mature activities (and hence 60% seed), outperform the mature, focused firm[vi].

Conclusions and suggestions for further research.

Our findings reveal that – under certain conditions – ambidextrous firms can indeed take on sustainable forms whereby sustainability is defined as resulting in overall value creation equal or superior to focused mature firms. In order for such a relative stronger performance to occur, different elements play a role: adopting longer time frames; being able to shift resources across different parts of the portfolio; and finally actively pursuing or enacting synergies which might affect both the inclination (b,b') and the upper limit (L) of the value curve analyzed here.

The most important impact on value is observed when synergies are being introduced. Synergies manifest themselves threefold: flexibility in terms of resource allocation across activities, technological cross-fertilization affecting b or b', and market development as reflected in L, which in its turn presupposes new applications and products resulting from cross-fertilization. While O'Reilly and Tushman (2004) recently added the idea of sharing resources to the characteristics of ambidextrous organizing, our analysis stresses the crucial role of cross-fertilization on the level of underlying technologies. As such, Rosenberg's adagio 'inside the black box' turns out to be highly relevant for firms pursuing continuous innovation. At the same time, our findings are in line with the empirical observations made by Teece et al. (1994) and He and Wong (2004). The interaction effect of exploration and exploitation activities on economical performance observed within this latter study might be directly related to the cross-fertilization dynamics outlined within this contribution. As such, these observations underscore the relevancy of further adopting interface management practices directed towards actively enacting synergies while at the same time attenuating the paradoxical tensions encountered.

At the same time, the observations reported here are but a first effort to model the value dynamics underlying ambidextrous, innovating firms. Additional analysis and refinements seem relevant and are actually being pursued by the authors. Such refinements relate to introducing multiple allocation models (implying portfolio's comprising more than just 2 activities); introducing market dynamics (see in this respect J. Sutton), as well as refining value creation and resource dynamics by including their unpredictable nature. Finally, empirical testing of the dynamics and relationships outlined in order to refine them seems highly appropriate.

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Figure 1: The Dual and Paradoxical Nature of Interaction

The Dual Nature of interaction in relation to Knowledge Creation Processes	
Exploitation: selection-execution-adaptation in an efficient manner	Exploration : search –discovery-experimentation-variation in an effective manner
Addressing Uncertainty; problem structure is given/shared but precise knowledge with respect to the (magnitude of) the variables and their inter-relationships is searched for.	Addressing Ambiguity: multiple/unclear viewpoints with respect to problem structure and its constituting variables
Handling Information Asymmetries	Coping with Interpretation Asymmetries
Predominant Characteristics of the relational field in which both activities unfold	
Homogeneity as facilitating/enabling with respect to (fast/efficient) information sharing	Heterogeneity as necessary/enabling in order to arrive at a novel analysis and synthesis (social marking)
Consensus and Cohesiveness	Conflict and tension

Figure 2: Value and Resource Relationships as defined for Diversified firms

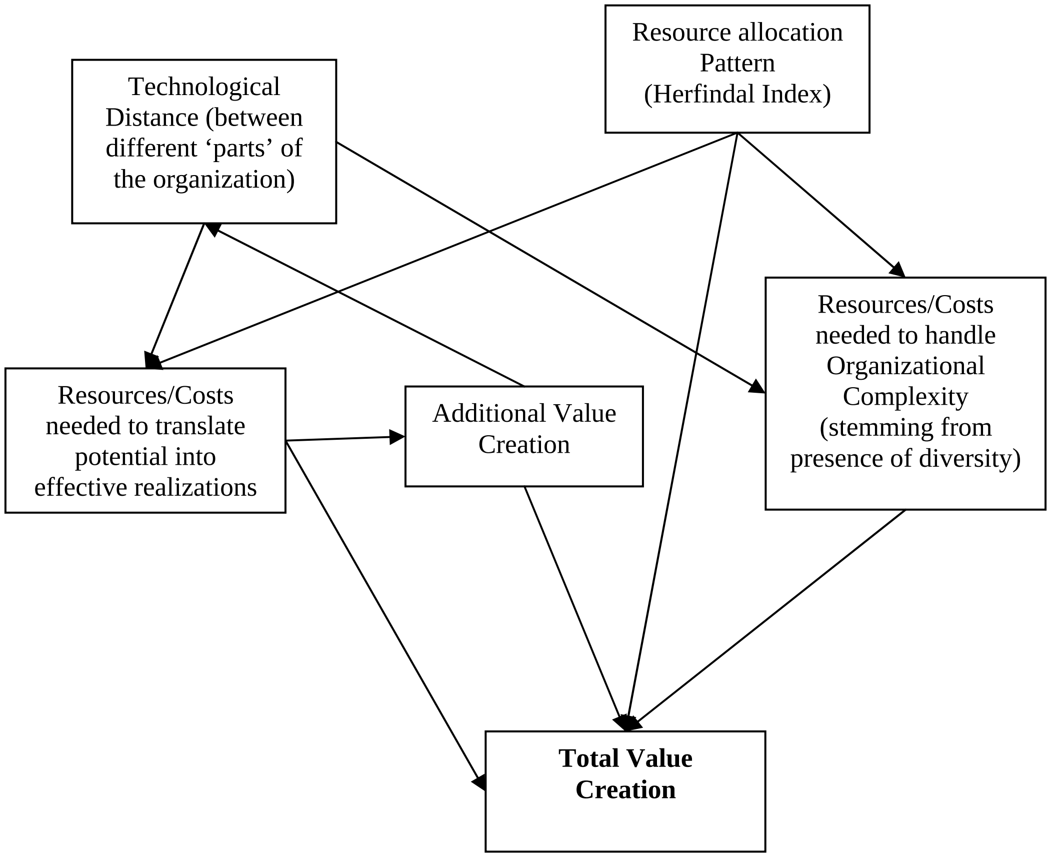

Table 1: Value creation for Focused Firms depending on Life Cycle stage and variation of b, b'.

	Seed	Growth	Mature	Decline
b, b'=0.1	5,22	225,92	382,91	394,78
b, b'=0.2	69,06	308,46	391,29	330,94
b, b'=0.3	169,95	338,92	394,19	230,05
b, b'=0.4	227,31	354,19	395,64	172,69

Table 2: Total Value Creation for Focused and Diversified firms over 3 time periods

	Focused Firm					**Diversified Firm (without shifts in resource allocation)**				
	Portfolio characteristics	*b'=0,1*	*b'=0,15*	*b'=0,2*	*b'=0,4*	*Portfolio characteristics*	*b'=0,1*	*b'=0,15*	*b'=0,2*	*b'=0,4*
Period 1	100% M	391,29	391,29	391,29	391,29	10%S/90%M	359,06	359,06	359,06	359,06
Period 2	100% D	394,77	377,43	330,92	172,68	10%G-M/90%D(*)	393,83	378,24	336,38	193,97
Period 3	100% D	267,08	82,65	14,44	0	10%M-D/90%D	279,98	112,86	48,15	20,27
Total		1053,12	851,37	736,65	563,97		1032,88	850,17	743,60	573,30

(S = Seed; G= Growth; M=Mature; D=Decline)

(*) During period 2, the diversified firm spans the growth phase to end already in the first episodes of Maturity at the end of period 2. Similar dynamics can be observed for Period 3, this time pertaining to Maturity and Decline.

Table 3: Costs encountered by the Diversified Firm over 3 time periods

Portfolio Characteristics	*b'=0,1*	*b'=0,15*	*b'=0,2*	*b'=0,4*
10%S/90%M	6,23	6,23	6,23	6,23
10%G-M/90%D	4,17	4,01	3,58	2,11
10%M-D/90%D	2,1	0,88	0,37	0,16
Total	12,5	11,12	10,18	8,5

(S = Seed; G= Growth; M=Mature; D=Decline)

Table 4: Total Value Creation for Diversified firms able to re-allocate resources over 3 time periods

	Diversified Firm shifting resources without constraints					Diversified Firm shifting resources gradually (5% each time period)				
	Portfolio Characteristics	*b'=0,1*	*b'=0,15*	*b'=0,2*	*b'=0,4*	*Portfolio Characteristics*	*b'=0,1*	*b'=0,15*	*b'=0,2*	*b'=0,4*
Period 1	10%S/90%M	359,06	359,06	359,06	359,06	10%S/90%M	359,06	359,06	359,06	359,06
Period 2	G/M	397,27	395,22	390,23	373,00	G/M	396,64	393,15	386,64	353,43
Period 3	M/D	383,20	354,56	317,82	182,40	M/D	383,20	354,56	317,82	182,40
Total		1139,54	1108,84	1067,11	914,47		1138,91	1107,26	1063,53	894,90

(S = Seed; G= Growth; M=Mature; D=Decline)

Table 5: Costs encountered by the Diversified firm able to shift resources over 3 time periods

	Diversified Firm shifting resources without constraints				Diversified Firm shifting resources gradually (5% each time period)			
	b'=0,1	*b'=0,15*	*b'=0,2*	*b'=0,4*	*b'=0,1*	*b'=0,15*	*b'=0,2*	*b'=0,4*
Period 1	6,23	6,23	6,23	6,23	6,23	6,23	6,23	6,23
Period 2	4,21	4,18	4,13	3,96	6,13	6,08	5,96	5,98
Period 3	2,85	2,64	2,37	1,4	2,85	2,64	2,37	1,40
Total 3 time periods	13,29	13,05	12,73	11,59	15,21	14,95	14,56	12,91

Table 6:Comparing Net Value Creation of Enacting, Diversified firms with Focused Firms over One Time Period

Mature/Seed = 90/10 ***b = 0,20***	***Mature/Seed = 10/90*** ***b = 0,20***

Net value creation in absolute terms

Mature/Seed = 90/10, b = 0,20

effect on L	*effect on b* +0.05	+0.1	+0.15	+.2
+0	356,82	362,44	366,57	369,63
+1	388,38	395,26	400,25	404,02
+2	419,58	427,71	433,70	438,18
+3	450,42	459,95	466,88	472,13
+4	481,02	491,94	499,92	505,89
+5	511,39	523,73	532,67	539,46
+10	659,40	679,48	694,16	705,21

Mature/Seed = 10/90, b = 0,20

effect on L	*effect on b* +0.05	+0.1	+0.15	+.2
+0	148,54	187,89	216,82	238,61
+1	159,46	203,28	235,57	259,91
+2	170,06	218,35	254,08	281,00
+3	180,32	233,18	272,32	301,84
+4	190,35	247,77	290,38	322,53
+5	200,14	262,13	308,22	343,03
+10	245,77	330,91	394,91	443,30

Net value creation expressed as % deviation from most performing focused firm (100%Mature) – One time period consisting of 40 episodes.

Mature/Seed = 90/10, b = 0,20

effect on L	*effect on b* +0.05	+0.1	+0.15	+.2
+0	-8,8 %	-7,4 %	-6,3 %	-5,5 %
+1	-0,7 %	1,0 %	2,3 %	3,3 %
+2	7,2 %	9,3 %	10,8 %	12,0 %
+3	15,1 %	17,5 %	19,3 %	20,7 %
+4	22,9 %	25,7 %	27,8 %	29,3 %
+5	30,7 %	33,8 %	36,1 %	37,9 %
+10	68,5 %	73,7 %	77,4 %	80,2 %

Mature/Seed = 10/90, b = 0,20

effect on L	*effect on b* +0.05	+0.1	+0.15	+.2
+0	-62,0 %	-52,0 %	-44,6 %	-39,0 %
+1	-59,2 %	-48,0 %	-39,8 %	-33,6 %
+2	-56,5 %	-44,2 %	-35,1 %	-28,2 %
+3	-53,9 %	-40,4 %	-30,4 %	-22,9 %
+4	-51,4 %	-36,7 %	-25,8 %	-17,6 %
+5	-48,9 %	-33,0 %	-21,2 %	-12,3 %
+10	-37,2 %	-15,4 %	0,9 %	13,3 %

Table 7: Comparing Net Value Creation of Enacting, Diversified firms with Focused Firms over three Time Periods

M/S = 90/10
b = 0,20
value = 1123,7

Net value creation in absolute terms

	effect on b			
effect on L	*+0.05*	*+0.1*	*+0.15*	*+0.2*
+0	1122,99	1129,02	1133,27	1136,34
+1	1231,08	1238,50	1243,62	1247,40
+2	1338,87	1347,60	1353,75	1358,23
+3	1446,29	1456,46	1463,60	1468,85
+4	1553,47	1565,10	1573,30	1579,28
+5	1660,32	1673,54	1682,72	1689,53
+10	2191,12	2212,47	2227,52	2238,63

Net value creation expressed as % deviation from most performing focused firm

	effect on b			
effect on L	*+0.05*	*+0.1*	*+0.15*	*+0.2*
+0	6,6%	7,2%	7,6%	7,9%
+1	16,9%	17,6%	18,1%	18,4%
+2	27,1%	28,0%	28,5%	29,0%
+3	37,3%	38,3%	39,0%	39,5%
+4	47,5%	48,6%	49,4%	50,0%
+5	57,7%	58,9%	59,8%	60,4%
+10	108,1%	110,1%	111,5%	112,6%

[i] An observation which can be related directly to the relevancy of composing R&D teams in a cross-functional or multidisciplinary manner as advanced repeatedly by scholars in the field (Cooper, 1979, Imai et al., 1985, Cooper & Kleinschmidt, 1987; Brown and Eisenhardt, 1996; Keller, 2001).

[ii] Sheremata (2000) outlined the various organisational dimensions which can be instrumental for finding an equilibrium between the 'centrifugal' and 'centripetal' forces at work in those situations; including Decentralization, Reach, Free Flow of Information, Connectedness, Project Management influence, Cross-functional team influence and Temporal pacing

[iii] See in this respect for instance the findings of Wernerfelt and Montgomery (1988).

[iv] Given the start conditions, the total value over three periods will be influenced most by b' as maturity and decline becomes relevant as from period 2.

[v] In general terms; enacting firms are able to reduce the difference with focused firms considerably – by merely enacting within one time period (and hence no re-allocation of resources) - when 50% or more of the resources are allocated to seed activities. When more than 50% is attributed to mature activities, enacting firms outperform focused firms as soon as delta b= 0,05 and L increases by 1 (10%).

[vi] These findings are not included in this paper, due to page constraints, however available from the authors upon request.