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Preventing or escaping the suppression mechanism: intervention conditions

Abstract

The benefits of strategically balancing exploitation and exploration are well documented in the literature. However, many firms tend to overemphasize exploitation efforts, even in the face of the strong need to step up their exploration activities. A process theory behind this phenomenon, the suppression mechanism, is further explored here. This process describes the interplay between top management (developing a perceived need to explore influenced by management myopia) and the board of directors as gatekeepers of the capital market (generating an external pressure to exploit) as severely limiting for the formation of a profitable and sustainable exploitation-exploration balance. We draw on system dynamics modeling to identify the critical intervention conditions required for organizations to prevent, or escape, the suppression mechanism. As such, the main theoretical contribution of this paper is the identification of critical intervention conditions (i.e. target, timing, size and duration).

Keywords: exploration-exploitation, firm failure, top management-board interaction, suppression mechanism, process theory, system dynamics modeling.

1. Introduction

After having struggled for survival during the beginning of the 1990s, IBM management successfully launched its Emerging Business Areas program around the year 2000; an initiative that led to the firms' remarkable comeback (O'Reilly III et al., 2009). IBM was founded in 1911 and its sustained presence on the market can be considered an exception, since only a small fraction of all (US) firms live beyond the age of 40 (Nystrom and Starbuck, 1988; Stubbart and Knight, 2006). To survive Schumpeterian environments, many firms must cope with increasingly complex products combined with progressively shorter product life cycles. In that respect, recent research has shown that the right balance between exploitation and exploration in relation to the dynamics of the environment vastly increases firm survival changes by positively influencing financial performance (He and Wong, 2004; Jansen et al., 2006; Uotila et al., 2009).

Firm survival thus depends on the firms' innovative competence combined with its talent for generating healthy returns on investments made in accordance with the dynamic environment (Leonard-Barton, 1992; March, 1991; Raisch and Birkinshaw, 2008). Some firms' extended existence in the market illustrates the ability to adapt to changing environmental situations by both exploiting existing competencies and exploring new opportunities (cf. Tushman and O'Reilly III, 1996). This capability is often described as organizational ambidexterity (Gupta et al., 2006; He and Wong, 2004; Raisch and Birkinshaw, 2008).

Nevertheless, many firms fail to develop organizational ambidexterity. Moreover, many authors observed that a focus on exploitation tends to reinforce itself, causing the suppression of exploration. This is also referred to as the 'success trap' (Gupta et al., 2006; Helfat et al., 2007; Smith and Tushman, 2005). Walrave and colleagues (2010) developed a process theory that captures the underlying causes of the success trap and coined this sequence of events the ‘suppression mechanism’. It provides a comprehensive answer to why, and how, some firms stick to an exploitation strategy until the point that firm survival is only achievable by drastic turnarounds (e.g. major reorganizations and/or acquisitions) (Helfat et al., 2007; Tushman et al., 2004).

However, the literature does not provide any answers/clues with regard to how to prevent, or escape, the suppression mechanism, thereby avoiding the need for major turnarounds. In this paper we explore whether firms can prevent or escape the suppression mechanism; and so, how and when interventions designed to stimulate organizational ambidexterity should be initiated. This makes it important to understand the *intervention conditions* (i.e. target, timing, size and duration) required to sustain, or restore the equilibrium between the exploitation and exploration activities and the firms’ environment. A better understanding will inform top managers about ways to design and execute more effective and efficient interventions, thereby reducing the chance of firm failure due to the suppression mechanism. This paper, therefore, explores the intervention conditions necessary to prevent, or escape, the suppression mechanism.

As such, this paper responds to calls for studies that examine how to achieve a dynamic balance between exploitation and exploration (Gupta et al., 2006; Smith and Tushman, 2005). This paper makes use of a simulation model. In this respect, simulation modeling is a key research method for addressing questions that unfold over time and are non-linear in nature (Davis et al., 2007; Romme, 2004; Romme et al., 2010; Walrave et al., 2010). SD presents a circular, closed-loop view of causality, aiming to improve our understanding about how things change over time (e.g. the balance of investments in exploitation and exploration). This makes SD modeling very suitable for this research. Simulation experiments serve to extend current knowledge related to the development of a sustainable exploitation-exploration balance.

In this paper we argue that both prevention of, and escape from, the suppression mechanism is possible provided that the intervention takes place in particular conditions. We contribute to the ambidexterity literature by codifying critical intervention conditions required for the development of organizational ambidexterity. As such, the main theoretical contribution of this paper to the exploitation-exploration literature is the identification of critical intervention conditions (i.e. target, timing, size and duration) required to prevent, or escape, the suppression mechanism (Walrave et al., 2010). Furthermore, knowledge related to restoring a sustainable exploitation-exploration balance is of high value for practice.

This paper has been organized in the following way. The next section presents the theoretical background of the model. Next, the simulation model is outlined and key features described. Subsequently, the simulation experiments are discussed to create a better understanding of the dynamics involved in the research question outlined earlier. Finally, theoretical and practical implications are presented, combined with opportunities for future work.

2. Theoretical Background

Mortality studies have shown that the majority of firms do not survive very long, with an expected residual life between 5.8 to 14.6 years (Foster and Kaplan, 2001; Stubbart and Knight, 2006). These findings raise the question whether organizations can adapt to changing environmental contexts; and if they were formerly able to, can they keep on adjusting to align with the environment over and over again? Research on this question has traditionally been performed in two main directions (cf. Barnett and Carroll, 1995). The first perspective states that firms cannot initiate change quickly or easily, and when they do, organizational failure is the most likely outcome (e.g. Hannan and Freeman, 1984; Nelson and Winter, 1982). This perspective draws on the evolutionary process of variation-selection-retention, in which environmental change triggers the replacement of inertial companies by new ones, better fitted to the changing/changed context. This variation-selection-retention process then constitutes the main cause of organizational change (Barnett and Carroll, 1995).

The second point of view considers firms capable to adapt and change following environmental stimuli. In that respect, organizational changes happen principally through these adaptive responses (Barnett and Carroll, 1995). Ideas concerning punctuated equilibrium (e.g. Burgelman, 2002), ambidexterity (e.g. Benner and Tushman, 2003), and dynamic capabilities (e.g. Teece et al., 1997) are inherently rooted in the idea that successful change is possible.

Therefore, depending on the perspective adopted, preventing or escaping a too large focus on exploitation is, or is not, likely. As outlined in the introduction, some firms do survive and prosper over extended periods of time. Yet, as noted by O’Reilly and Tushman (2008), for every well-known success there is also a well-known failure. Polaroid and Caterpillar can serve as examples of the latter group (cf. Tripsas and Gavetti, 2000; Tushman et al., 2004). In that respect, both perspectives can be grounded in empirical data. The variation-selection-retention versus adaptation discussion has consequently evolved in an attempt to understand under what conditions organizations will be able to sustain their competitive advantage (O'Reilly III and Tushman, 2008). This paper contributes to this relatively new line of research that incorporates, among others, organizational ambidexterity.

Ambidextrous firms can be defined as firms that are able to simultaneously exploit existing competencies and explore new opportunities in alignment with the environmental context (Raisch et al., 2009). Exploitation extends current knowledge by achieving greater efficiency and improvements to enable incremental innovation and adaptation; exploration involves the development of new knowledge needed for radical innovation which is likely to decrease the value of current knowledge and products (Andriopoulos and Lewis, 2009; Atuahene-Gima, 2005). In that respect, ambidexterity requires two essentially different and often-competing strategic acts to be carried out at the same time (Simsek et al., 2009; Smith and Tushman, 2005). Different types of offerings developed by the firm are often competing for the same limited set of resources available. As a consequence, an increase in exploitation activities (in the short run) decreases the amount of resources available for exploration efforts, and vice versa. We, therefore, assume that exploitation and exploration are two ends of one continuum, and firms have to create a strategic balance between the two ends with the current set of resources (Gupta et al., 2006; March, 1991).

Our focus here is on large publically held manufacturing-oriented firms. Many of these firms are mainly focusing on the production of their current offering, implying a focus on mainly exploitation activities. Nevertheless, publically held firms have access to the capital market, providing the possibility to make investments in exploration initiatives. These firms can, therefore, build ambidexterity as they typically have the resources required to do so. For instance, it has been shown that large firms can successfully embark upon technologically difficult innovation (i.e. exploration); even developments that require very different competencies than currently possessed (Christensen and Bower, 1996). Moreover, larger firms can spread some of the risk related to exploration by running several programs simultaneously;

this unlike small firms which usually have to bet on a single offering. Nonetheless, the mortality rate among large firms is high.

Hence, large firms tend to be technically fit, but may lack evolutionary fitness (cf. Helfat et al., 2007). Technical fitness relates to the performance of the offering not considering the context (e.g. market situation), whereas evolutionary fitness relates the offering to the specific environment. In that respect, evolutionary fitness is a function of a firms technical fitness combined with the (ever changing) market situation (comprised of demand and competition) and determines firm survival (Helfat et al., 2007). Evolutionary fitness can thus only be achieved by organizational adaptation in line with the changing context. This also implies that managing for ambidexterity is a dynamic rather than static task as the 'optimal' balance is constantly shifting. In order to survive, organizations have to continuously reconfigure their activities in order to cope with changing environments (Raisch et al., 2009). March (1994) referred to this as evolutionary engineering.

The tension originating from simultaneously accomplishing exploitation and exploration with a given amount of resources is usually resolved at the next organizational level down (Raisch et al., 2009). In that respect, a system may construct different subsystems with diverging responsibilities. For instance, a firm can consist of different business units with different roles, a business unit could contain different teams with different foci; even a team could have assigned different roles to different individuals. This has also been called architectural ambidexterity (Andriopoulos and Lewis, 2009), and involves highly differentiated units which permit firms to simultaneously explore as well as exploit. Nevertheless, at the top of those systems, top management has to develop the capability to guide their firm to become ambidextrous and is, therefore, key to sustained organizational performance

(Gupta et al., 2006; He and Wong, 2004; Smith and Tushman, 2005; Tushman and O'Reilly III, 1996). Organizational ambidexterity is thus for an important part driven by top managements "internal processes that enable them to handle large amounts of information and decision alternatives and deal with conflict and ambiguity", (Tushman and O'Reilly III, 1997, p.23).

Top managers' cognitive structures shape their actions that subsequently influence their organizations' actions (Nystrom and Starbuck, 1988). From a cognitive perspective, top management acts on a shared mental model; a simplified representation of the world that facilitates decision making processes (Tripsas and Gavetti, 2000). A cognitive frame, the equivalent of a mental model, refers to a construct which is (relatively) stable over time and creates the context for complex reasoning (Doyle and Ford, 1998; Tripsas and Gavetti, 2000). We define a mental model as: "a dynamic system that is relatively enduring and accessible, but limited, internal conceptual representation of an external system whose structure maintains the perceived structure of that system" (Doyle and Ford, 1998, p.17). A mental model serves as the foundation for cognitive processes, which refer to the behavioral routines and ways managers think about and respond to information (Smith and Tushman, 2005; Tripsas and Gavetti, 2000). In the context of this research, the mental model needs to capture the *perceived need to explore*.

It has been argued that a mental model's stability originates from the inertial forces that develop over time, restricting the rate at which the cognitive map of top management can change (Hannan and Freeman, 1984; Tripsas and Gavetti, 2000). This implies that information accumulated in a mental model is always partially outdated, consequently reducing the speed at which top management can respond to changes in the environment. Nevertheless, this does not always explain why some firms are not able to change the corporate strategy at all; inertial forces mainly delay the adjustment of top management's mental model. Indeed, Hannan and Freeman (1984, p.151) argued: "To claim that organizational structures are subject to strong inertial forces is not the same as claiming that organizations never change."

Top management is exposed to a variety of sources that cause external pressure inhibiting the balancing act between exploitation and exploration (Wood and Bandura, 1989). In this respect, we argue that the owners of the firm constitute the main source of external pressure in publicly held firms (also as gatekeepers of the influence of the capital market on the firm). Owners, represented by the board of directors, have great interest in earning a maximum amount of money with a reasonable degree of risk (Berle and Means, 1932; Singh and Harianto, 1989). For this, they hire a top management team to direct and coordinate activities within the firm. The board of directors then monitors the performance of top management, and has the power to hire, fire, and compensate top management and to ratify and monitor major decisions (Fama and Jensen, 1983; Singh and Harianto, 1989). In that sense, the board appears to possess the power to significantly influence the strategic direction (Baysinger et al., 1991; Finkelstein, 1992).

As such, boards can claim a central role in corporate governance processes (Forbes and Milliken, 1999; Singh and Harianto, 1989). For instance, Hambrick and Finkelstein (1987) found that boards with powerful outside shareholders have the leverage to limit managerial discretion. Moreover, Baysinger et al. (1991) found evidence that firms with large outside shareholders follow different strategies compared to those firms without such shareholders. In that sense, it is likely that during times that shareholder wealth generation is assured, the board's influence on the strategic direction will be relatively small compared to times of financial decline.

The main role of the board then is to provide advice and expertise to top management (Bacon, 1973). However, during times of financial decay, the board can use its power to force the generation of short-term financial results (Judge and Zeithaml, 1992; Singh and Harianto, 1989), by means of forced exploitation investments and/or abandoning exploration activities.

A firm can, therefore, get locked into the suppression mechanism due to cognitive incapability (resulting in an underestimation of the perceived need to explore), external pressure to exploit, or by a combination of both. This subsequently undercuts the (ongoing) development of organizational ambidexterity and ultimately results in severe underperformance, if not firm failure, due to the suppression mechanism. Organizational ambidexterity can thus be considered as a function of cognitive processes and external pressure that combined shape strategic decision making concerning the balance between exploitation and exploration. This paper examines this interaction in more depth. More specifically, by focusing on these two impediments on the development of organizational ambidexterity, the intervention conditions that allow a firm to prevent, or escape, the suppression mechanism will be investigated.

3. Model Description

Investigating different ways to prevent and escape the suppression mechanism (by configuring different management-board relationships) does not lend itself readily to experimental analysis in actual organizational settings. A simulated environment, therefore, allows the researcher to systematically vary the theoretically relevant variables, after which the impact on organizational performance can be assessed. Hence, simulation provides an excellent vehicle for systematic investigation of the conditions that facilitate prevention, or escape of the suppression mechanism, by adjusting the perceived need to explore and external pressure to exploit variables in the formal model.

We draw on System Dynamics (SD) modeling to simulate the formal model. SD particularly serves to investigate multiple interacting processes, time delays, and other nonlinear effects (e.g. Davis et al., 2007; Oliva and Sterman, 2001; Repenning, 2001; Romme, 2004). The SD model used is characterized by a so-called capacitated delay structure (Sterman, 2000). This implies that the impact of a set of related stocks (e.g. perceived need to explore and external pressure to exploit) is dependent on the level of in and out flows of these stocks. Moreover, each of these flows are influenced and constrained by external constitutions as well as the levels of multiple stocks (cf. Sterman, 2000). This makes SD very suitable to create an understanding of systems that are characterized by dynamic complexity (Sterman, 2000). Moreover, SD based differential equations provide a well-developed modeling and simulation tool for tracking and explaining processes that involve tangible as well as intangible variables (e.g. ‘operating result’ versus ‘perceived need to explore’) (Sterman, 2000). In that respect, system dynamics has been successfully applied to investigate strategy issues (Risch et al., 1995; Sterman, 2000; Walrave et al., 2010).

The model in this paper was adopted from Walrave et al. (2010) and, as such, this section will only briefly outline the model. A full description of the model, including all equations and settings (including the sensitivity of the settings), is given in a separate document that can be obtained upon request from the authors. The model includes the main feedback loops with respect to managerial decision making on ambidexterity by capturing the interplay between the perceived need to explore and the external pressure to exploit. Figure 1 provides a stylized overview of the model.

INSERT FIGURE 1 ABOUT HERE

The model captures the development of organizational ambidexterity in three feedback loops. The first reinforcing process, the ‘Stick to exploitation’ loop, captures top management’s cognitive process (their perceived need to explore) and the influence of inertia on the mental model. Investments in exploitation combined with a stable environment results in a positive operating result, and hence, no need to further explore. Change in the external context, however, triggers investments in exploration, albeit with a certain delay due to inertial forces. Second, the balancing ‘Limits to change’ loop represents the effect of the board of directors on the strategic decision making process. As argued, the level of external pressure is determined by the trend of the financial performance. A positive trend in the financial performance creates discretional space for top management to both exploit and explore, while a negative trend increases the pressure to exploit. The third and last process, the reinforcing ‘Attempt to explore’ loop captures the effect of the resource investment in exploration efforts. After a certain delay, exploration investments pay off, reducing the long-term investment limitations imposed by the board, consequently allowing for further investments in exploration. In essence, once this reinforcing process develops into the dominant loop, the firm in the model prevents, or escapes, the suppression mechanism.

Although the original model allows for the assessment of the outcomes of specific interventions, it is not possible to estimate the intervention costs. This could make a specific intervention successful in terms of preventing or escaping the suppression mechanism, but also highly unrealistic from a resource point of view. In order to consider the financial viability of the different interventions, the opportunity costs need to be assessed. This measure reflects the costs associated with choosing between (two) mutually exclusive ends. More specifically, it captures the costs associated with the choice of reducing exploitation investments as a result of dedicating more resources to exploration efforts. For example, top management might want to start more exploration activities in order to be better able to react to environmental changes. Nevertheless, this implies that fewer resources will be available for exploitation. On the short term, this is likely to decrease the operating result. For instance, investing in exploration could result in very high opportunity costs due to *creative destruction* (cf. Schumpeter, 1942). The opportunity costs will, therefore, give a better reflection of the intervention costs than the (fixed) costs of the operation itself. As such, the original model was expanded by adding the 'Opportunity costs' variable.

The mathematical procedure to be added to the model description.

In order to calculate the opportunity costs (opp_costs), the model needs to compare the calibrated case OR against the simulated (intervened) OR. In this respect, the situation 'as is' needs to be compared against to 'what could have been'. As shifting the balance towards more exploration will normally have a negative short-term effect on the OR, the missed return on exploitation investments need to be captured, while neglecting the long-term profits. As such, the opp_costs can be calculated as:

d (opp_costs) / dt = IF THEN ELSE (OR (calibrated data) – OR (simulated run) < 0, OR (calibrated data) – OR (simulated run), 0)

Capabilities are often a matter of degree (Winter, 2000), and can, therefore, be modeled as continuous variables. As such, the perceived need to explore (PNE) variable ranges from 0 to 1; 0 implies a mere focus on exploitation while 1 denotes an exclusive focus on exploration. The external pressure to exploit (EP) to exploit variable also ranges from 0 to 1. Here, 1 means that only exploitative investments are allowed. On the other end, a value of 0 gives top management the opportunity to freely invest in both exploitation and exploration.

The model was calibrated with data obtained during a case study at a firm that got locked in the suppression mechanism due to a combination of inertial forces and external pressure. It concerns a large Dutch manufacturing firm that manufactures and sells a diverse range of textile related products. The firm took advantage of a relatively stable environment for many years and enjoyed a substantial growth by pursuing an exploitation strategy. However, the competitive dynamics were growing and the inertial forces slowed down the relative adjustment of the firm in terms of the development of organizational ambidexterity. In that sense, top management was very slow with directing organizational change. This in its turn triggered external pressure to exploit, trapping the firm in the suppression mechanism. As a consequence, at the moment of writing the firm is in the midst of a major reorganization (cf. Walrave et al., 2010).

Adopting the described model and context allows for experimentation with the relevant variables: by adjusting the perceived need to explore, the effect of interventions that lower the inertia levels can be simulated. Moreover, varying the external pressure to exploit variable resembles the situation in which interventions decrease such pressure to exploit. As such, it makes it possible to configure different top management – board relationships and assess the outcome ceteris paribus. The calibrated model thus serves as a starting point to determine what intervention conditions should be present in order to prevent, or escape, the suppression mechanism. Figure 2 and 3 illustrates the perceived need to explore, external pressure to exploit, operating result, and environmental dynamism of the investigated firm over a time period of 780 weeks (1994 till 2009).

INSERT FIGURE 2 ABOUT HERE

INSERT FIGURE 3 ABOUT HERE
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4. Experimentation and Results

Using the model outlined in the previous section, we simulate the conditions which are instrumental in preventing or escaping the suppression mechanism. More specifically, so-called *if-then* simulation experiments serve to establish the intervention conditions required to achieve this goal. Three experiments are set up. The first one relates to top management's perceived need to explore. In this respect, a decreased level of inertia allows top management to react faster to environmental changes and will thus result in earlier exploration investments; a method often described to prevent the success trap (and thus the suppression mechanism) (Burgelman et al., 2004; Nystrom and Starbuck, 1988). Nevertheless, after a period of increased exploration, a phase of exploitation likely follows in which the newly gained assets are capitalized. In that sense, by modeling an intervention that lowers the influence of inertia (by stepwise increasing the perceived need to explore variable), for a specific amount of time, we can test this commonly stated proposition as technique to prevent, or escape, the suppression mechanism. As such, the first experiment will focus on top managements' cognition only.

The second experiment concerns the influence of the board of directors on the balance between exploitation and exploration. A lower pressure to exploit during times that exploration investments are needed is critical to prevent, or escape, the suppression mechanism. Only then will top management be empowered to make long-term investments. Nonetheless, even if the board allows enhanced investments in exploration activities, this will likely only be temporary in nature. After a specific amount of time the firm (top management) will thus have to start exploiting the results of the exploration initiatives. This situation can be modeled by temporarily (stepwise) decreasing the external pressure to exploit variable.

The last experiment relates to the interaction between the perceived need to explore and external pressure to exploit. It simulates an intervention that successfully influences both top management and the board of directors to adjust the balance between exploitation and exploration. It consequently combines the first two experiments and reflects the situation in which there is an increased perceived need to explore, together with a decreased external pressure to exploit. This can be simulated by the simultaneous, but temporal, adjustment of both variables.

All experiments are conducted with so-called *STEP* changes to the perceived need to explore and/or the external pressure to exploit variable. The perceived need to explore variable is (stepwise) increased and/or the external pressure to exploit variable (stepwise) decreased over a specific time period. The resulting enhanced level is subsequently only susceptible to the normal systems' dynamics for a specific duration throughout the simulation experiments. After this period, the level of the variable(s) will be (stepwise) adjusted in the opposite direction.

More specifically, during the initial period of change, these two variables are (in addition to their natural adjustment due to the systems dynamics) incrementally increased and/or decreased with a 0.1 percent change per week. For the perceived need to explore variable this implies that the balance (and thus exploration investments made) has the potential to shift with 0.1 percent per week. The impact that an intervention has during this period of adjustment is called the *intervention* *effect size*. For example, in order to achieve an intervention effect size of 5 percent (e.g. a 5 percent increase in the perceived need to explore), the period of change has to equal almost a year. This resembles a perhaps rather slow, but realistic adjustment to the variables.

The amount of time that the variables remain in an enhanced state is denoted with *intervention effect duration*; that is, the period in which the intervention continues to have an effect. It represents top managements', or the boards', stamina to hold on to the newly set balance between exploitation and exploration. After the intervention effect duration, the variables will be subject to a (stepwise) change in the opposite direction that is twice the original intervention effect size. This simulates the organizational attempt to exploit the newly gained assets. Figure 4 further illustrates, besides the hypothetical behavior of an intervention targeted at top management, the difference between intervention effect size and intervention effect duration.

INSERT FIGURE 4 ABOUT HERE

Determining the effectiveness of the selected experiments requires a further specification of success. The results of the experiments will be assessed at t = 780 weeks (equal to the year 2009), the end of the calibrated model period (see Figure 2 and 3), in order to determine if the interventions were successful. Hence the suppression mechanism needs to be further delineated. Because the suppression mechanism constitutes a process theory (cf. Walrave et al., 2010), a characterization of the start of this process is needed, which can then be compared to the simulated results at t = 780. In this respect, the start of the suppression mechanism is defined as the moment in which the external pressure to exploit variable exceeds the value 0.5. Effectively, this denotes the state in which top management is deprived of the majority control on resource distribution. As a consequence, the firm will adjust increasingly slower to the changing environmental context; an important starting point of the suppression mechanism[1].

With respect to the above, the intervention effect size *tipping points* will be determined. More precisely, the tipping points represent the minimum intervention effect size needed, in order to achieve an external pressure to exploit lower than 0.5 at t = 780. The tipping points are important because, once crossed, the systems' dynamics undergo a fundamental change (cf. Rudolph and Repenning, 2002). In this respect, when an intervention has a smaller effect size than the tipping point indicates, the firm will get caught in the suppression mechanism; and vice versa. Every experiment will be run with three (fixed) intervention effect durations; a 52, 104, and 260 week interruption between increase and decrease; resulting in three scenarios per experiment. This ensures that interventions with both short-term and long-term effect durations are being assessed. In this respect, shorter effect durations (< 52 weeks) are not likely to result in prevention of, or escape from, the suppression mechanism. Longer intervention effect duration (> 260 weeks) seem practically impossible.

The mathematical procedure to be added to the model description.

In order to determine the tipping points, Mircosoft Visual Basic (within excel) was utilized in combination with Vensim. The code below illustrates how the intervention effect size tipping points were determined by means of Dynamic Data Exchange (DDE). This specific example was targeted at the perceived need to explore variable

[1] Following this definition the investigated firm started to get trapped at t = 242 weeks. This implies that, for the situations in which $t < 242$ weeks, the prevention of the suppression mechanism will be investigated. From $t \geq 242$ weeks, simulation experiments will focus on escaping the exploitation trap.

with a duration of 52 weeks. Simple adjustments to this code allows for the investigation of other scenarios.

```
Sub open_model()
        Dim DDE_channel As Integer
        DDE_channel = Application.DDEInitiate("VENSIM", "System")
        Application.DDEExecute DDE_channel, [SPECIAL>LOADMODEL|model_location_and_name
        Application.DDETerminate DDE_channel
End Sub
Sub experiment_1()
        Dim DDE_channel As Integer
        DDE_channel = Application.DDEInitiate("VENSIM", "System")
        Application.DDEExecute DDE_channel, "[SPECIAL>NOINTERACTION|1]"
        Application.DDEExecute DDE_channel, "[SETTING>SHOWWARNING|0]"
        Dim Pulse_1_start As Long
        Dim Pulse_1_duration As Long
        Dim Cell As Long
        Dim operating_result As Long
        Dim returnList As Variant
        Dim ch1 As Long
        Dim ch2 As Long
        Dim ch3 As Long
        Dim ch3a As Long
        Dim ch3b As Long
        Pulse_1_start = 0
        Pulse_1_duration = 0
        Cell = 2
        Do While Pulse_1_start <= 780
Pulse_1_duration = 0
operating_result = 0
Do While Pulse_1_duration <= 200

Application.DDEExecute DDE_channel, "[Simulate>SETVAL|Pulse 1 duration=" & Pulse_1_duration & "]"
Application.DDEExecute DDE_channel, "[Simulate>SETVAL|Pulse 1 start=" & Pulse_1_start & "]"
Application.DDEExecute DDE_channel, "[Simulate>SETVAL|Step decrease on/off=2]"
Application.DDEExecute DDE_channel, "[Simulate>SETVAL|Step decrease relative start=52]"
Application.DDEExecute DDE_channel, "[MENU>RUN|O]"
Application.Wait (Now + 0.00001)
varstr$ = " ""External pressure to exploit (motivation) (EP)""@780"
test = Application.DDERequest(DDE_channel, varstr$)
external_pressure = test(LBound(test))
If (external_pressure < 0.5) Then Exit Do
Pulse_1_duration = Pulse_1_duration + 100

        Loop
Pulse_1_duration = Pulse_1_duration - 100
        Do While Pulse_1_duration <= 200

Application.DDEExecute DDE_channel, "[Simulate>SETVAL|Pulse 1 duration=" & Pulse_1_duration & "]"
Application.DDEExecute DDE_channel, "[Simulate>SETVAL|Pulse 1 start=" & Pulse_1_start & "]"
Application.DDEExecute DDE_channel, "[Simulate>SETVAL|Step decrease on/off=2]"
Application.DDEExecute DDE_channel, "[Simulate>SETVAL|Step decrease relative start=52]"
Application.DDEExecute DDE_channel, "[MENU>RUN|O]"
Application.Wait (Now + 0.00001)
varstr$ = " ""External pressure to exploit (motivation) (EP)""@780"
test = Application.DDERequest(DDE_channel, varstr$)
external_pressure = test(LBound(test))
If (external_pressure < 0.5) Then Exit Do
Pulse_1_duration = Pulse_1_duration + 25

        Loop
Pulse_1_duration = Pulse_1_duration - 25
        Do While Pulse_1_duration <= 200

Application.DDEExecute DDE_channel, "[Simulate>SETVAL|Pulse 1 duration=" & Pulse_1_duration & "]"
Application.DDEExecute DDE_channel, "[Simulate>SETVAL|Pulse 1 start=" & Pulse_1_start & "]"
Application.DDEExecute DDE_channel, "[Simulate>SETVAL|Step decrease on/off=2]"
Application.DDEExecute DDE_channel, "[Simulate>SETVAL|Step decrease relative start=52]"
Application.DDEExecute DDE_channel, "[MENU>RUN|O]"
Application.Wait (Now + 0.00001)
varstr$ = " ""External pressure to exploit (motivation) (EP)""@780"
test = Application.DDERequest(DDE_channel, varstr$)
```

```
external_pressure = test(LBound(test))
If (external_pressure < 0.5) Then Exit Do
Pulse_1_duration = Pulse_1_duration + 1

        Loop

varstr$ = "Pulse 1 start@" & Pulse_1_start
 returnList = Application.DDERequest(DDE_channel, varstr$)
Sheets(number).Cells(Cell, number).Value = returnList(LBound(returnList))

varstr$ = "Pulse 1 duration@" & Pulse_1_duration
returnList = Application.DDERequest(DDE_channel, varstr$)
Sheets(number).Cells(Cell, number).Value = returnList(LBound(returnList))

varstr$ = " ""Operating result (OR)""@780"
returnList = Application.DDERequest(DDE_channel, varstr$)
Sheets(number).Cells(Cell, number).Value = returnList(LBound(returnList))

varstr$ = " ""Operating result cumulative (ORC)""@780"
returnList = Application.DDERequest(DDE_channel, varstr$)
Sheets(number).Cells(Cell, number).Value = returnList(LBound(returnList))

 varstr$ = " ""Perceived need to explore (cognition) (PNE)""@780"
returnList = Application.DDERequest(DDE_channel, varstr$)
Sheets(number).Cells(Cell, number).Value = returnList(LBound(returnList))

varstr$ = " ""External pressure to exploit (motivation) (EP)""@780"
returnList = Application.DDERequest(DDE_channel, varstr$)
Sheets(number).Cells(Cell, number).Value = returnList(LBound(returnList))

varstr$ = "Total investment costs@780"
returnList = Application.DDERequest(DDE_channel, varstr$)
Sheets(number).Cells(Cell, number).Value = returnList(LBound(returnList))

Cell = Cell + 1
Pulse_1_start = Pulse_1_start + 1
Loop

Application.DDETerminate DDE_channel
End Sub
```

Experiment 1

As outlined, the first experiment relates to top managements' ability to prevent, or escape, the suppression mechanism; thereby assuming that an intervention can decrease the influence of inertial forces for a specific amount of time. This seems to be a robust assumption seen the findings of Smith and Tushman (2005). In this respect, such an intervention could, for instance, stimulate an increase in the level of differentiating cognitive processes. This could subsequently results in more exploration investments. Later, integrative cognitive processes force top managers to focus on exploitation once more (cf. Smith and Tushman, 2005). This experiment thus investigates the intervention effect size required (given a certain intervention effect duration) to increase the perceived need to explore to such a degree that it results in prevention of, or escape from, the suppression mechanism. In that sense, by systematically adjusting the perceived need to explore variable, the tipping points can be determined. Figure 5 and 6 illustrate the results of this experiment.

The interpretation of the results for this first experiment will be discussed more extensively to allow the reader get familiar with tipping point analyses. Figure 5 denotes the tipping points for the three different intervention effect durations. Every point in the graph represents a tipping point that belongs to that specific point in time for that specific intervention effect duration. The graphs should, therefore, not be interpreted as a continuous lines unfolding over time. For example, an intervention that started at t = 104 and is targeted at the perceived need to explore variable should possess an intervention effect size that is smaller than one percent (for an intervention effect duration of 260 weeks) to prevent the suppression mechanism at t = 780 weeks (2009). Following that same logic, Figure 5 denotes the total opportunity costs of an intervention that stated at a given t, with a given effect duration, at the end of the model run (t = 780). For example, the opportunity costs equal roughly 8 million Euros at the end of the model run for an intervention that started at t = 416 and has an effect duration of 260 weeks (with an intervention effect size that is minimally required to escape the suppression mechanism). For all the graphs in this section goes that results with required an intervention effect size larger than 20 percent are omitted, as this, following our assumption, would take 200 weeks to accomplish; a questionable long time span for interventions to occur in practice.

INSERT FIGURE 5 ABOUT HERE

INSERT FIGURE 6 ABOUT HERE

The results in Figure 5 suggest that both prevention and escape from the suppression mechanism is possible by decreasing the influence of inertial forces on top managements' cognition; thereby increasing their perceived need to explore. The three selected intervention effect durations resulted in different tipping points; the longer the period between the increase and decrease, the smaller the intervention effect size needed to prevent, or escape, the suppression mechanism. Moreover, the opportunity costs were found to be lower in most of the cases as well (see Figure 6).

The results also suggest the existence of different phases in which different intervention effect sizes are needed to prevent or escape suppression. More specifically, interventions can be labeled as 'too early', 'early', 'just in time', 'late', or 'too late'. First of all, the 'just in time' intervention phase for this experiment ranged from t = 191 till t = 306. During this period, only a small intervention effect size is required to prevent, or escape, the suppression mechanism, which is almost equal for all three intervention effect durations. Moreover, the short-term opportunity costs were found to be low.

The next time period, 'too early' interventions, ranged from t = 0 till t = 11. Too early interventions were characterized by high opportunity costs and high required intervention effect sizes. These costs were large enough to trap a firm in the suppression mechanism. The phase 'early' ranged from t = 12 till t = 190. It was characterized by high (but decreasing) required intervention effect sizes and opportunity costs. Nevertheless, the opportunity costs reduced with longer intervention effect durations.

Whereas short-term opportunity loss constitutes the biggest problem for (too) early interventions, the intervention effect size required comprised the largest obstacle for 'late' interventions. This period ranged from t = 307 till t = 484. This makes interventions at this stage ($t > 307$) increasingly difficult, if not impossible. Longer intervention effect durations resulted in both smaller required interventions sizes and opportunity costs. In the last period, ‘too late’, $t \geq 485$, the suppression mechanism is unavoidable due to intervention effect sizes that are not achievable.

Experiment 2

We now turn to the influence of the board of directors. The second experiment, therefore, investigates the influence that an intervention aimed at decreasing the external pressure to exploit can have, by creating a greater resource allowance for exploration activities. In that respect, this experiment determines the minimum required intervention effect size needed to decrease the external pressure to exploit to such a degree that the suppression mechanism can be circumvented. Figure 7 and 8 present the results of this experiment.

INSERT FIGURE 7 ABOUT HERE

INSERT FIGURE 8 ABOUT HERE

The results in Figure 7 indicate that an intervention resulting in a decreased external pressure to exploit can have enough influence on the balance between exploitation and exploration to prevent, or escape, the suppression mechanism. Nevertheless, in order to achieve the desired outcome, larger intervention effect sizes (on average) were needed compared to the first experiment. However, the opportunity costs remained (on average) lower (see Figure 8). Similar to the first experiment is that the different intervention effect durations gave different tipping points. More specifically, longer intervention effect durations resulted in smaller intervention effect sizes required to avoid the suppression mechanism. Moreover, the same five periods could be identified.

The ‘just in time’ phase ranged from t = 301 till t = 321; a significantly smaller time span compared to the first experiment. Nevertheless, it was also characterized by both a small intervention effect size requirement and low opportunity costs. The ‘too early’ time period ranged from t = 0 till t = 43 and required high opportunity costs and large intervention effect sizes (likely to trap the firm into the suppression mechanism). Interestingly, the results from the run with a 260 weeks intervention effect duration did not suffer from the high opportunity costs (although the intervention effect sizes required remained large). The ‘early’ phase ranged from t = 44 till t = 300 and had large, albeit rapidly decreasing, requirements concerning the intervention effect size. The same holds for the opportunity costs in this phase. The ‘late’ intervention period was also found to be particularly small compared to the first experiment, ranging from t = 322 till t = 410. It is characterized by a steep increase in the required intervention effect size. Nevertheless, the longer the intervention effect duration, the smaller the required intervention effect size. Last, the ‘too late’ phase started from t = 411; 74 weeks earlier compared with the first experiment.

Experiment 3

This experiment simulates a greater perceived need to explore combined with a decreased external pressure to exploit. As such, it investigates how the interaction between top management and the board of directors can contribute to avoiding, or escaping, the suppression mechanism. More specifically, it determines the minimum required intervention effect size (given an intervention effect duration) aimed at both the perceived need to explore and the external pressure to exploit variable, to prevent, or escape, the suppression mechanism. We assume that the interventions will take place at the same time and will have the same intervention effect duration. Figure 9 and 10 illustrate the results of this experiment.

INSERT FIGURE 9 ABOUT HERE

INSERT FIGURE 10 ABOUT HERE

The results, as illustrated in Figure 9, indicate that a successful interaction between top management and the board of directors can result in prevention of, and escape from, the suppression mechanism. The results were, to some extent, comparable to the two former experiments. However, the required intervention effect size was found to be (on average) lower. Once more, the longer the intervention effect duration the smaller the required intervention effect sizes and the lower the opportunity costs (see Figure 10). Moreover, the same five phases could be identified.

The ‘just in time’ intervention phase ranged from t = 194 till t = 341 and was characterized by small required intervention effect sizes and low opportunity costs. That indicates that this particular intervention setup extended this phase with an additional 36 weeks compared to the first experiment; or an additional 20 weeks compared to the second experiment. The results of the ‘too early’ and ‘early’ phases were found to be almost identical to the findings of the first experiment; these interventions were once more characterized by (too) high opportunity costs. The former ranged from t = 0 till t = 12; while the latter ranged from t = 13 till t = 193. For ‘too early’ interventions it was found longer intervention effect durations resulted in smaller required intervention effect sizes.

Moreover, for ‘late’ interventions a decrease in the required intervention effect size was found compared to the first experiment. This period ranged from t = 342 till t = 500, and was once more characterized by a positive influence of intervention effect duration on the intervention effect size. The *t* after which any intervention becomes ineffective, ‘too late’ interventions, was found to be 16 weeks later compared to the first experiment, at *t* = 501; or 90 weeks later compared to the second experiment.

5. Discussion

Figure 11 provides an overview of the findings. It compares the three experiments by averaging the results (required intervention effect sizes) per experiment, while omitting results with opportunity costs larger than 15 million Euros. From this figure, it becomes clear that the different phases require different intervention designs in order to prevent, or escape, the suppression mechanism. This put an emphasis on the importance of intervention timing for the development of organizational ambidexterity.

INSERT FIGURE 11 ABOUT HERE

This research identified five different phases in which intervention can occur: too early, early, just in time, late, and too late. Each phase possess different characteristics and, therefore, requires a different intervention design in order to prevent, or escape, the suppression mechanism. Timing, in the context of ambidextrous development, was already mentioned by March (1991) to be an important determinant for the successful deployment of exploitation versus exploration efforts. O’Reilly and Tushman (2008) also touched upon the subject by stating that there should be consensus among the top management team concerning the resource allocation *and* timing in order to act upon opportunities and threats in a timely manner. Levinthal and March (1993, p.103) discussed the issue of timing as well, but placed it in the context of short-term versus long-term learning and the potential pitfalls of determining the “variety and depth of knowledge to be added to the inventory". Moreover, Hannan and Freeman (1984) already stated that one of the most important (and shared) issues in the evolutionary-ecological theories concerns the timing of issues. Nevertheless, to the best of our knowledge, no research has related intervention timing with intervention design.

First of all, interventions that are designed and executed 'too late' have no chance of being successful (see Figure 11). These interventions are differentiated by very high, and therefore unlikely, required intervention effect sizes to escape the suppression mechanism. Top management waited too long with adjusting to the new external context and the environmental context has already changed to such a degree that interventions aimed at increasing the perceived need to explore and/or decreasing the external pressure to exploit cannot be effective anymore. As described in the literature, firm survival now depends on drastic turnarounds (Helfat et al., 2007; Tushman et al., 2004).

Interventions designed and executed 'too early' will likely result in high opportunity costs, which can be high enough to trap the firm in the suppression mechanism. This can be explained by the fact that if the firms' balance between exploitation and exploration is still in line with its environment (see Figure 11), the firm will incur high opportunity costs due to (too early) *creative destruction* (cf. Schumpeter, 1942). That is, if the external environment, the companies' strategy, and belonging internal structures are still aligned, there is a great risk that short-term possibilities are decayed by changing the balance between exploitation and exploration. This partly contradicts the thesis that early investments in exploration will prevent firms from getting trapped in the success trap (Levinthal and March, 1993; Tushman et al., 2004), and thus the suppression mechanism. As such, it seems that postponing interventions might sometimes help in sustaining the evolutionary fitness of the firm (Helfat et al., 2007). Nonetheless, interventions designed to decrease the external pressure to exploit that possess a large intervention effect size and long intervention effect duration can be 'safely' initiated in a stable environmental context; this unlike all other interventions (see Figure 7 and 8; intervention effect duration 260 weeks). This might be explained by the fact that even if the board of directors permits increased exploration investments, this does not imply that top management will actually invest in exploration. This can (and it did in this model) result in large delays between the start of the intervention and the start of actual exploration investments. As such, this makes long intervention effect sizes and durations a (unfeasible) requirement for success. This provides an interesting perspective on the effect and requirements of too early investments.

It can be argued that 'early' exploration investments can result in a change of the external context by the introduction of radical innovation; much like, for instance, the introduction of the automobile or personal computer. Nevertheless, new markets emerge slowly (Burgelman et al., 2004), making early investments expensive in terms of opportunity costs. As the results indicated, these costs tend to decrease as the market develops over time. Interestingly, and similar to the former phase, interventions executed during this phase are best designed to decrease the external pressure to exploit (Figure 11; Experiment 2). Nevertheless, large intervention effect sizes are needed in order to prevent the suppression mechanism making that interventions executed during this phase have a low probability of success.

The 'just in time' phase is characterized by low intervention effect size requirements and low opportunity costs (see Figure 11). This implies that if a firm is able to adjust its balance between exploitation and exploration during this phase, the chance of successfully preventing, or escaping, the suppression mechanism will be big. This can be explained by intervention design that allows for the timely adjustment of the firms' balance in correspondence with the movement of the external context, while keeping the opportunity costs low. As such, this phase constitutes the best moment to prevent, or avoid, the suppression mechanism. Interventions executed during this phase are best designed to increase top managements' perceived need to explore (Figure 11; Experiment 1). Top management has a large influence on the strategic direction and as such has the capability to shift the balance relatively swiftly accordingly the environmental change. Moreover, during this phase the external pressure to exploit is still relatively low so (see Figure 2).

Interventions that are executed 'late'; that is, after the discussed intervention sweet-spot, are characterized by a rapidly increasing required intervention effect size in order to escape the suppression mechanism (see Figure 11). It concerns the situation in which the external context has already changed considerably. As such, the opportunity costs are lower as exploitation efforts become less profitable due to the sustained development of new markets. However, in this situation, the firm still needs to fundamentally adjust its balance between exploitation and exploration in order to align with the changed environmental context. In order to achieve this, interventions should be designed and executed that both increase the perceived need to explore and decrease the external pressure to exploit. Doing so can significantly lower the required intervention effect size during this phase and prevent the firm from getting fully trapped in the suppression mechanism (Figure 11; Experiment 3). As such, in order to escape the suppression mechanism during this phase, the problem of how to approximate the optimal alignment of interest between management and the board needs to be addressed.

The results indicated that stamina is a critical antecedent for interventions designed to develop organizational ambidexterity. All simulation experiments clarified that interventions designed with longer effect durations had a better chance of preventing or escaping the suppression mechanism; as stamina reduced the required intervention effect size. In that sense, this research clearly illustrates the importance of stamina when it comes to changing the balance between exploitation and exploration, an aspect that has not yet received much attention in the ambidexterity literature.

6. Conclusion

All firms will ultimately fail; it is an average, normal result for a firm (Stubbart and Knight, 2006). Nevertheless, some firms survive considerably longer than others, which raises the question how these organizations are able to sustain their competitive advantage. Research has shown that a key element for organizational survival, by maintaining a competitive advantage, is the ability to develop and sustain organizational ambidexterity (He and Wong, 2004; Uotila et al., 2009); that is, the talent to balance exploitation and exploration in alignment with the firms' environmental context. Nevertheless, more than some firms are getting trapped in the over-exploitation of their current assets (cf. Helfat et al., 2007). Moreover, in some cases a focus on exploitation tends to reinforce itself, limiting a firms' ability to move along with the external context (Gupta et al., 2006; Helfat et al., 2007; Levinthal and March, 1993; Smith and Tushman, 2005). A process theory behind this phenomenon, the success trap, is also referred to as the suppression mechanism (cf. Walrave et al., 2010).

Papers that serve to facilitate an understanding of how organizations can become or sustain organizational ambidexterity are scares. This paper, therefore, explored the intervention conditions that are paramount in the prevention of, or escape from the suppression mechanism. A focus was placed at top management, seen their large influence on the corporate strategy (Adner and Helfat, 2003) and, therefore, on the balance between exploitation and exploration (Tushman and O'Reilly III, 1997). In that respect, this paper investigated interventions targeted at top managements' cognition (to increase their perceived need to explore) and interventions aimed at the board of directors (to reduce the external pressure to exploit). For this, the system dynamics model developed and calibrated by Walrave et al. (2010) was adopted. This model incorporates the main feedback loops with regard to managerial decision making on ambidexterity by capturing the interplay between the perceived need to explore and the external pressure to exploit variable. Moreover, it was calibrated with data gathered from a firm that got caught in the suppression mechanism; making it especially suitable for this research. Simulation experiments were conducted with this model to uncover the intervention conditions paramount to avoid, or escape from, the suppression mechanism.

This paper identified critical intervention conditions required for organizations that are attempting to change their balance between exploitation and exploration in order to prevent, or escape, the suppression mechanism. As such, the main theoretical contribution of this paper is the identification of critical intervention conditions (i.e. target, timing, size and duration). These findings also have important managerial implications. The results suggest that prevention of, or escape from, the suppression mechanism is possible if the intervention design fulfills certain requirements. Table 1 provides an overview of all requirements and characteristics. This table is designed for a specific context; large manufacturing firms characterized by long periods of environmental stability.

Table 1: intervention conditions required to build organizational ambidexterity.

Timing		Target		Size	Stamina	
Intervention to be conducted in phase	Change in environmental context	Required intervention target: *Board of directors*	Required Intervention target : *Top management*	Main obstacle to overcome	Importance of intervention effect duration, 'stamina'	Chance of success (in order to avoid the suppression mechanism)
Too early	None	X		Opportunity costs & intervention effect size	Critical	Highly Unlikely
Early	Small (1 year)	X		Opportunity costs & intervention effect size	Critical	Small
Just in time	Sustained (1 till 3 years)		X	-	Moderate	High
Late	Progressed (More than 3 years)	X	X	Intervention effect size	Critical	Moderate
Too late	Out of reach (after 2nd major change)	X	X	Intervention effect size	-	Highly unlikely

Simulation modeling inherently presents limitations to the presented research as the biases of the researchers are undoubtedly included in the model. Nevertheless, that is why simulations should be used to elaborate on emerging theories by deductive logic and empirical evidence. In that sense, the best use of simulation is between theory building and theory testing (Davis et al., 2007). The findings presented in this paper should, therefore, be subject to further empirical research.

Several interesting directions for future research can be pointed out. The model utilized in this paper assumed that individual ambidexterity (at top management level) automatically diffuses in organizational ambidexterity. However, not much is known concerning the transition of a strategy striving for ambidexterity to actual (ambidextrous) operational processes. In that respect, managerial influence is usually limited as in organizational environments, managerial goals must be socially transmitted. As such, managerial effort alone does not ensure attainment of a group goal (Wood and Bandura, 1989). Structural and cultural aspects further limit this transition (Tushman and O'Reilly III, 1996). The formal model took this into account by delaying the vertical diffusion process. Nevertheless, more knowledge related to this 'how' question is, therefore, critical for top management teams that are attempting to build ambidextrous capabilities. As such, more research should be devoted to this top-down transition process.

In this study, we considered large stock listed firms where the role of CEO is explicitly separated from the role of corporate board member. However, in some firms the CEO might be a large shareholder of the firm (e.g. family owned). In these situations, we can expect different findings. Lubatkin et al. (2006), for instance, found that family ownership has a significant, positive correlation with the ambidextrous orientation of the firm. In that respect, a top-manager with significant shareholdings in an organization has more power than a manager without such assets (Finkelstein, 1992). Moreover, managers, that are also the founders, hold more power through their often long-term interaction with the board (Finkelstein, 1992). Future research should address this situation in more depth by investigating the ambidexterity dynamics in family owned businesses.

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8. Figures

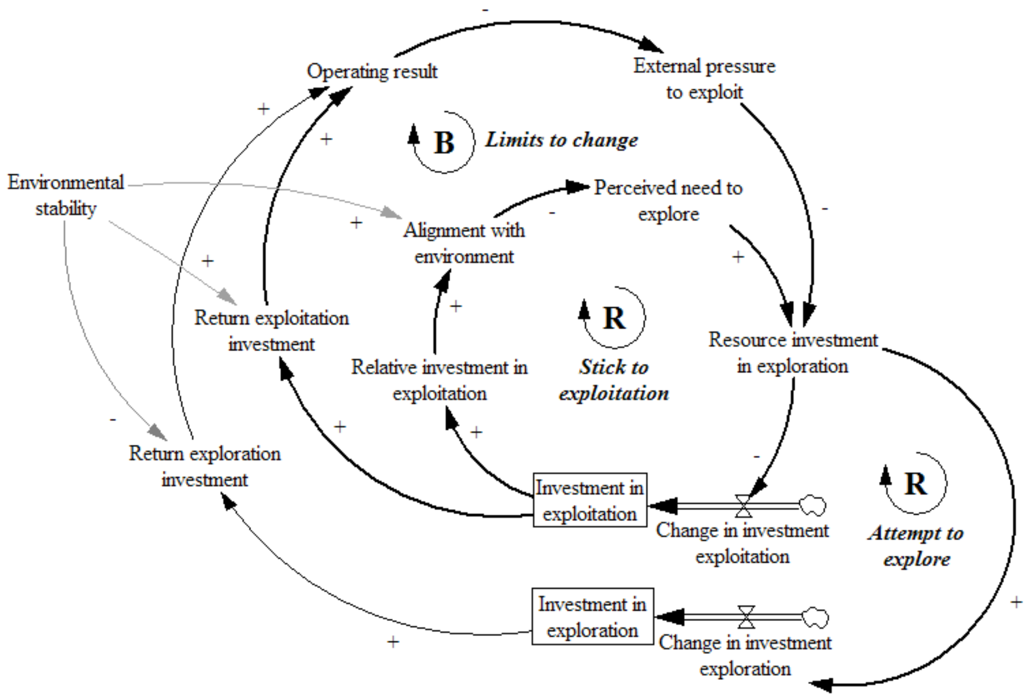

Figure 1: Stylized stock and flow diagram of the formal model.

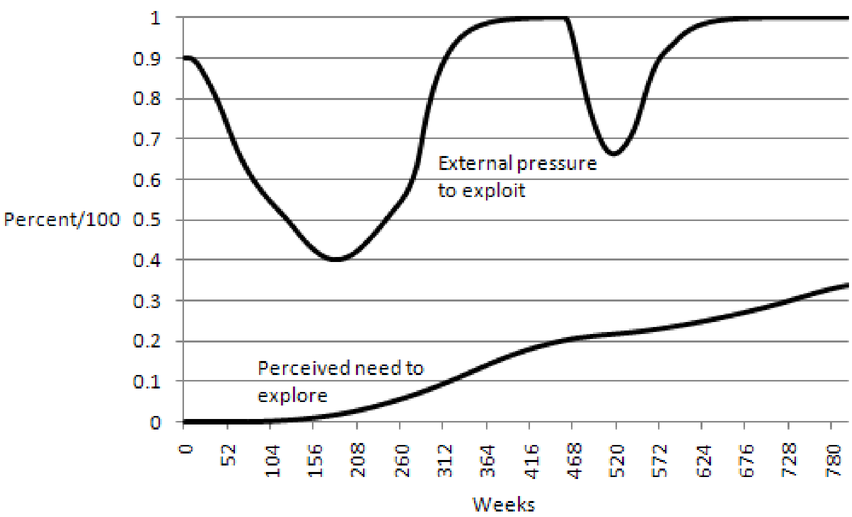

Figure 2: The calibrated "perceived need to explore" and "external pressure to exploit" variables.

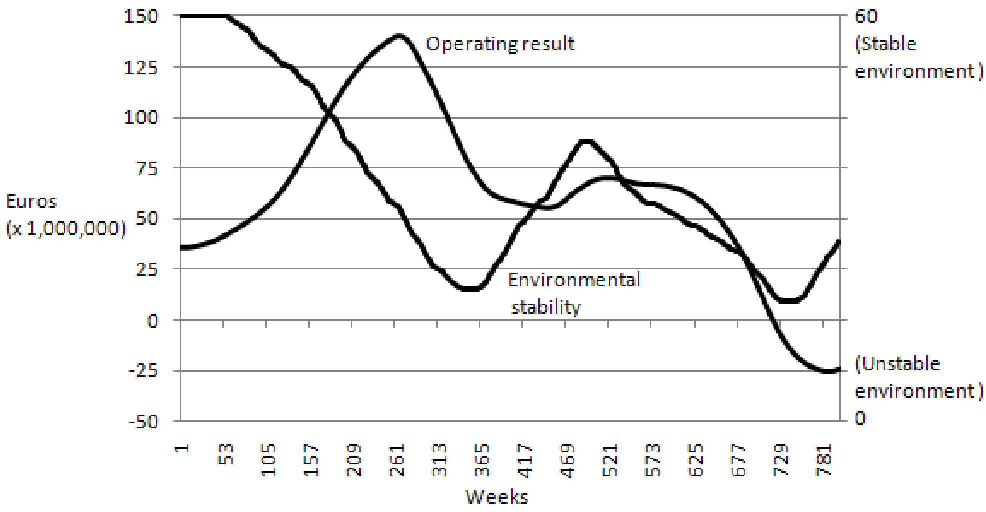

Figure 3: The calibrated "operating result" and "environmental stability" variables.

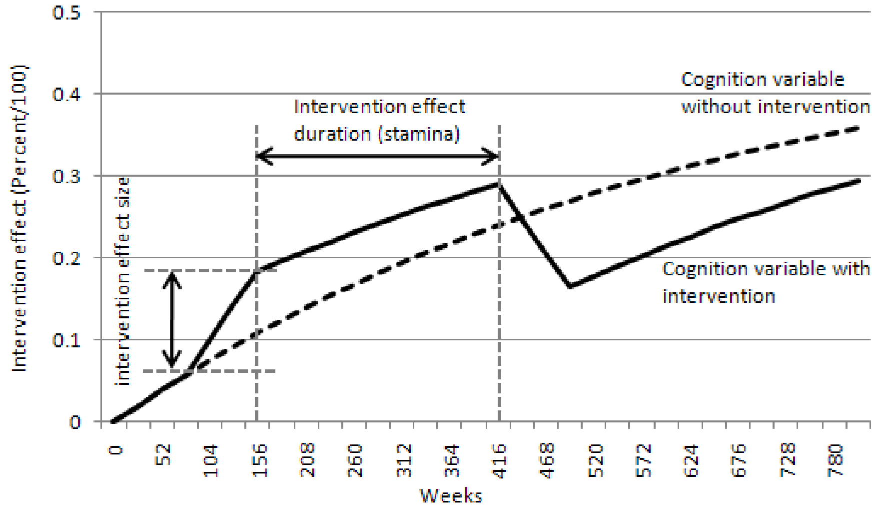

Figure 4: Illustration of the difference between intervention effect and effect duration.

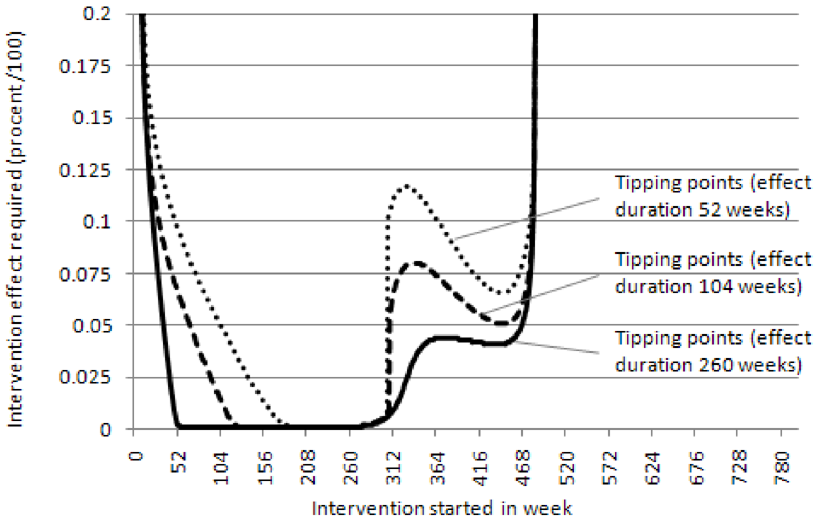

Figure 5: Tipping point analysis for the perceived need to explore variable (experiment 1).

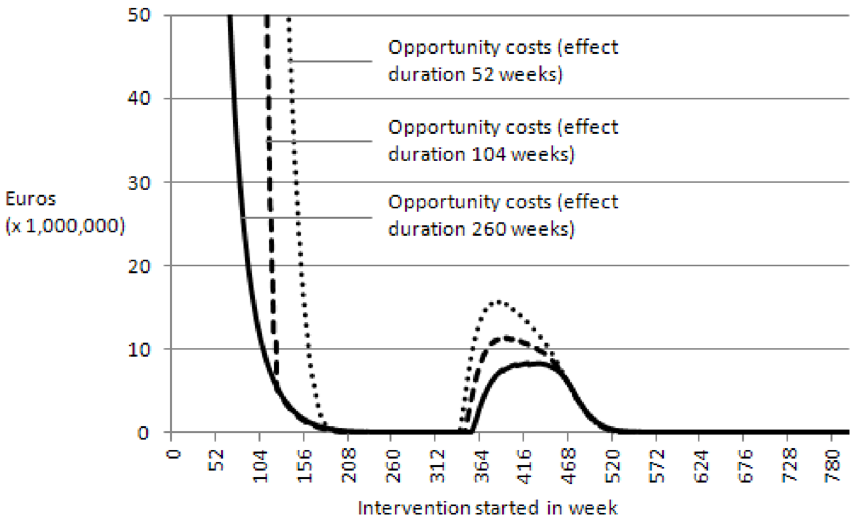

Figure 6: Opportunity costs for the required intervention effect size (experiment 1).

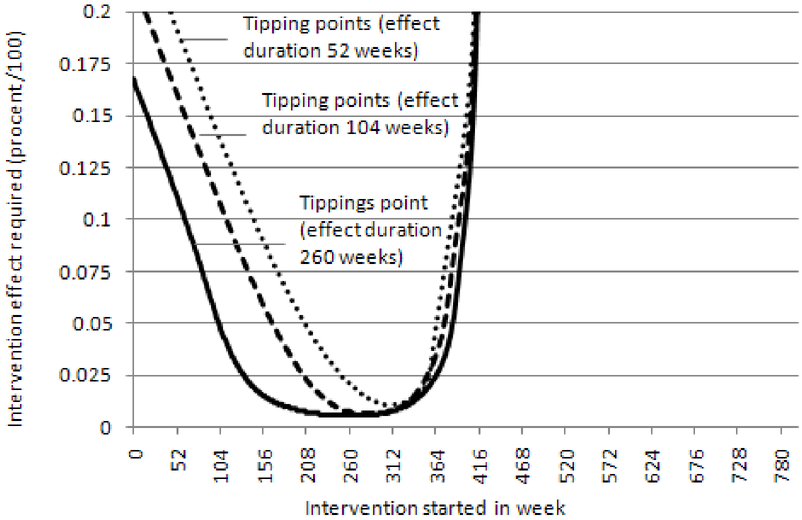

Figure 7: Tipping point analysis for the external pressure to exploit variable (experiment 2).

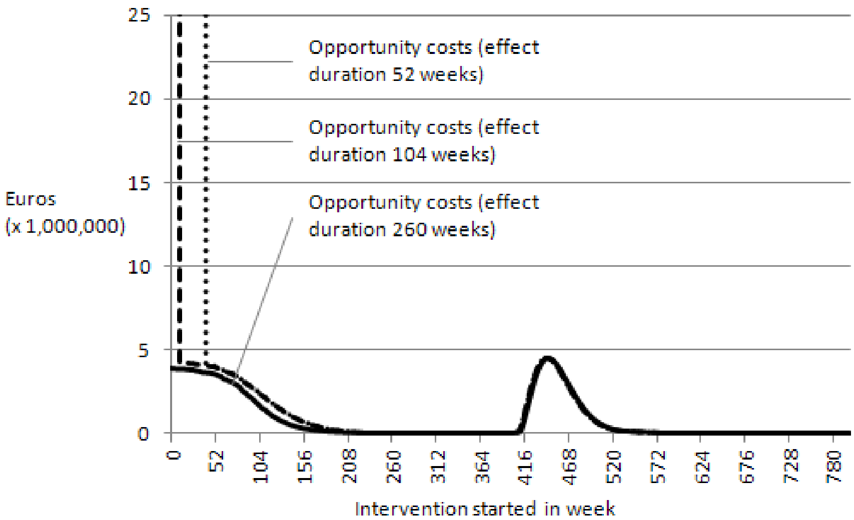

Figure 8: Opportunity costs for the required intervention effect size (experiment 2).

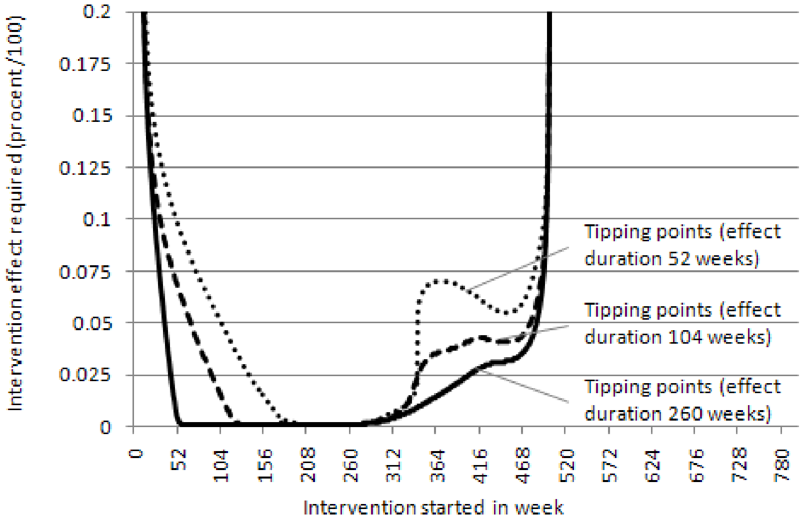

Figure 9: Tipping point analysis for the interaction between the perceived need to explore and the external pressure to exploit variable (experiment 3).

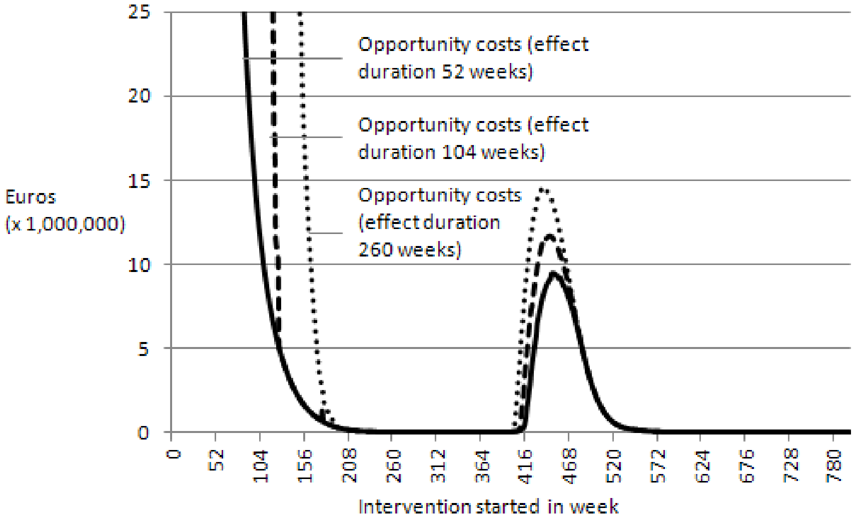

Figure 10: Opportunity costs for the required intervention effect size (experiment 3).

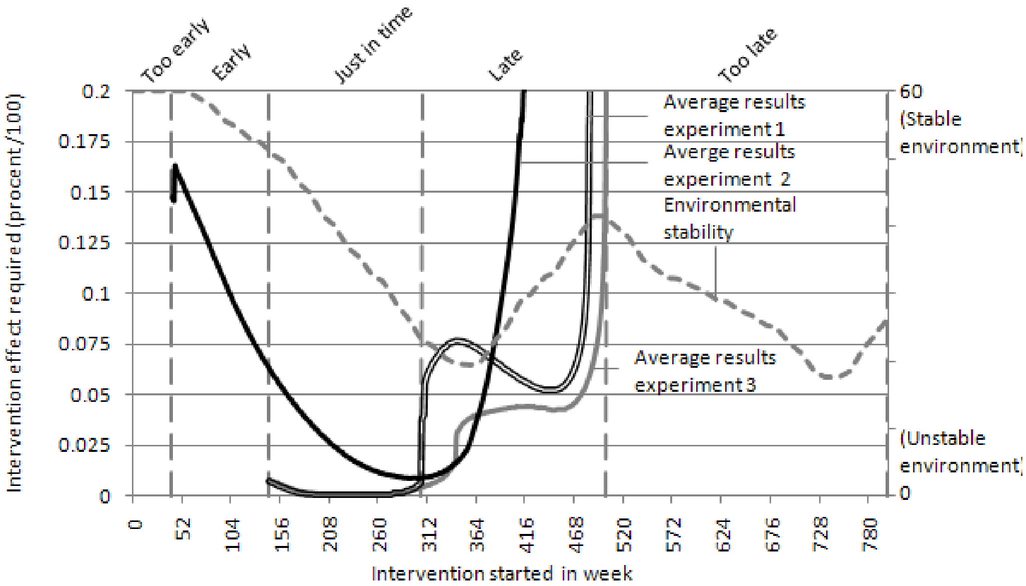

Figure 11: Summary of the three experiments (averaged per experiment) combined with the environmental stability variable.

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