The process behind the failure trap phenomenon

Koops, Daniël

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The Process Behind the Failure Trap Phenomenon

By Daniël Koops

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Supervisors:

dr.ir. B. Walrave

prof.dr. A.G.L. Romme
TU/e School of Industrial Engineering.

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Abstract – Many scholars emphasized the importance of a balance between exploration and exploitation efforts in relation to the firms’ performance. Too much emphasis on exploration at the expense of exploitation could at some point trigger the failure trap. This is an irreversible state where the firm engages in a frenzy of unsuccessful innovation, without financial rewards, draining the firms’ resources up to a point of bankruptcy. This study contributes by gaining a better understanding of the failure trap and the processes that drive this phenomenon. Since the failure trap implies the failure of innovations, this study also contributes to increasing the success rate of new innovations. Previously conducted research is used to derive several possible managerial forces that could get the firm caught in the failure trap. Next, system dynamics modeling is used to test one of those factors and investigate how it could disrupt the exploration and exploitation balance. This force, named the Innovation Impatience Effect, is a state where management does not grant newly introduced innovations enough time to fully reach their potential and unjustly rejects them as failure. If a firm is constantly underperforming, the pressure on management and decline in resources will at some point increase impatience, creating a negative reinforcing effect. The simulation indeed shows that the Innovation Impatience Effect alone is capable of getting the firm caught in the failure trap. A mismatch between perceived portfolio values, actual value and targets is, beyond a certain tipping point, capable of triggering a quick increase in exploration efforts. This is done at the expense of exploitation, up to a degree where the company is left with many potentially great ideas, but no means to commercialize them.

Introduction
Innovation plays an important role in our economy and its growth. One of the first to link innovation to growth was Smith (1776), who named improvements in machinery, and the sale of those as a (partial) cause for the wealth of nations. Decades later, Schumpeter (1934) concluded that capitalism simply cannot exist without innovations. The same goes for companies operational in a capitalistic system; in order to stay competitive they need to keep innovating or else the competition will take over their market share.

There are two main ways for organizations to learn, namely exploration and exploitation. First mentioned by Schumpeter (1934) as the exploration of new possibilities and the exploitation of old certainties, Levinthal & March (1993) linked these concepts to organizational learning, where exploration means the acquisition of new knowledge to the firm, or even to the market. Exploitation aims at the repetition of existing knowledge to be able to use it more efficiently. The general consensus is that organizations need to utilize both strategies to be able to maintain performance (Liu, 2006, March, 1991, Uotila, Maula, Keil, & Zahra, 2009); new knowledge, while costly and risky, can be exploited in the future for commercial purposes and help pay for the creation of new knowledge. Without the acquisition of new knowledge, the company eventually becomes obsolete. For this interaction between exploration and exploitation to become profitable, an optimal balance between the two has to be found. This balance is different for each company, and determined by many factors such as market dynamics or intensity of competition (Güttel & Konlechner, 2009).

The simultaneous pursuit between both exploration and exploitation, and finding an optimal balance between the two, is called ambidexterity (Gupta, Smith, & Shalley, 2006). Negative performance
implications caused by an imbalance between exploration and exploitation has been found by several scholars (Lee & Huang, 2012, Lin & McDonough, 2011, Raisch, Birkinshaw, Probst, & Tushman, 2009). Since the majority of resources are finite in practice (money, manpower, etc.), an imbalance means either an excess of exploitation at the expense of exploration, or vice versa. One could argue knowledge is an infinite resource (Gupta et al., 2006), but the creation of knowledge does require finite resources.

In the first scenario, where exploitation accelerates at the cost of exploration, the company is focused on the short term. The exploitation of available knowledge is less risky, and can be done at lower cost, than the creation of new knowledge (Levinthal & March, 1993). The revenues of exploiting knowledge are also more certain on the short term, which for example is favored by shareholders pressuring management for increasing operating results (Walrave, Van Oorschot, & Romme, 2011). On the long term, however, exploitable knowledge will become obsolete from, for example, technological breakthroughs or the efforts of competitors. If the company failed to acquire new knowledge and keep up with the competition, such a situation could mean the end of the organization. This situation is called a success trap; the successes of current activities lead to the neglecting of new knowledge creation.

The opposite of the success trap, and the main subject of this study, is the situation where exploration drives out exploitation. This situation, first mentioned by March (1991), later defined as the failure trap by Levinthal & March (1993), is acknowledged as a state where companies engage in frenzies of failing experimentation, change, and innovation. This places a continuous drain on resources without immediate financial reward and can eventually lead to the depletion of resources and bankruptcy of the company. Compared to the success trap, not much is known about the failure trap. Scholars generally agree that it can, or might occur in situations with excessive exploration (Baumann & Martignoni, 2011, Gupta et al., 2006, Uotila et al., 2009), but no research has been conducted on how the failure trap actually unfolds itself, and what forces drive the phenomenon.

The aim of this study is, therefore, to gain better insight in the process underlying the failure trap, and fill this void in the literature of organizational learning and strategic management. Since the failure trap implies the failure of innovations, this study also contributes to increasing the success rate of new innovations, which adds to an organizations overall performance. It is reasonable to assume that the failure trap can be triggered by either external and/or internal forces. Due to time constraints only the internal, managerial forces are examined, since they can add most to practical relevance; after all it is easier to manage those than, say, the competition or an entire market environment.

More concrete, this research has the aim to explain how the underlying managerial dynamics and processes drive organizations into a failure trap. This research question will be investigated by answering the following sub-questions:

1. **What are the managerial forces that could drive organizations into the failure trap;**
   *The answer to this sub-question will follow from a literature review, examining the theoretical background of the failure trap.*

2. **Which of those forces seems most interesting to be modeled and examined more closely;**
   *The answer to this sub-question will follow from a case study.*
3. Is this force actually capable of triggering a failure trap, and how does the failure trap unfold; 
   The answer to this sub-question will follow from simulating the hypothesized process using 
   system dynamics modeling.

4. What are the implications for managers dealing with similar situations? 
   The answer to this sub-question will follow in conclusion from the answering of the previous sub-
   questions.

Theoretical Background
To get from innovation to the ‘failure trap’ concept, first a distinction is made between the two main 
ways for organizations to learn; exploration and exploitation. This distinction was already mentioned in 
1912 by Schumpeter (1934) who studied the relation between the exploration of new possibilities and 
the exploitation of old certainties. However the work of March (1991) has been seminal to the field of 
exploration and exploitation, since they were the first to make a fundamental distinction between 
exploration and exploitation and their relation to organizational behavior (Gupta et al., 2006, Lavie, 
Stettner, & Tushman, 2010). March (1991, p. 71) defines exploration as ‘to include things captured by 
terms such as search, variation, risk taking, experimentation, play, flexibility, discovery and innovation. 
Whereas exploitation includes things such as refinement, choice, production, efficiency, selection, 
implementation and execution.’

The definitions where later reformulated by many, such as Jansen, Van Den Bosch, & Volberda (2006) 
who state that exploration refers to radical innovation and is designed to meet the needs of emerging 
customers or markets. Conversely, exploitation refers to incremental innovation and is designed to meet 
the needs of existing customers or markets. Levinthal & March (1993) link the exploration – exploitation 
subject to organizational learning, where exploration means the acquisition of new knowledge to the 
firm, or even to the market. Exploitation aims at the repetition of existing knowledge to be able to use it 
more efficiently.

While there still is no consensus on the definitions of both exploration and exploitation (Gupta et al., 
2006), the general idea of the two concepts seems to be clear. This study will use the definitions for 
exploration and exploitation used to appoint organizational learning processes (March, 1991). This view 
is more appropriate in this research than, say, that of Jansen et al. (2006) since the focus is set to top-
management decision making and how this can drive a dynamic process such as the failure trap. Since 
managers will also base decisions on what they have learned over time, the learning point of view and 
the definition that exploitation is about the improvement and refinement of existing organizational 
routines and competencies, while exploration is about the development of fundamentally new ones, is 
fitting (J. H. Moore & Kraatz, 2011).

Performance Implications of Exploration and Exploitation
March (1991) elaborates on the performance implications by saying that exploration has higher risk and 
systematically less certain returns that are also more remote in time. Therefore organizations tend to 
favor exploitation because it has opposite characteristics; less risk and shorter term revenues. However, 
only focusing on exploitation, on the long run, proves to be self-destructive (Luzon & Pasola, 2011). So if
a firm that sees a growth in demand for its current products does not seek new avenues in products, markets, systems and technology, it runs the risk of dying of success. So, some kind of balance between the two is required.

Organizations tend to engage more in activities wherein they are competent (Levinthal & March, 1993), so they get even better in those activities and the gap between exploration and exploitation widens. As organizations learn from experience over time, they also seemingly develop a bias caused by myopia. Organizations tend to become shortsighted in three ways; the short run is privileged at the cost of endangering the long run, they tend to ignore the bigger picture, and form a tendency to overlook failures (Levinthal & March, 1993).

The performance implications are examined by Uotila et al. (2009), who found a curvilinear relation between the relative exploration orientation of a firm and its financial performance. They also found a positive moderation effect of technological dynamism on this curvilinear relation (also see figure 1). Therefore, an optimum exists in the amount of exploration and its effect on performance; too little or too much is both harmful for the firms performance. These findings appear invalid for industries with a low R&D intensity. At first this seems logical; R&D will not pay off in industries with a very low overall R&D intensity. However, this study doesn’t take the effect in account that current R&D could have in the future performance of the firm.

He & Wong (2004) obtain similar results, saying that the interaction between exploration and exploitation positively relates to the sales growth rate. Consequently they also found that relative imbalance, or absolute difference, is negatively related to sales growth. Jansen et al. (2006), show that environmental dynamism and competitiveness moderate the effect of exploration and exploitation on financial performance. One should therefore keep in mind that balancing the strategies might not always lead to enhanced performance and other factors could also play a part in this. The feeling of an optimal balance might therefore never be reached. Another critical note was stated by Lavie et al. (2010) who emphasize the lack of differentiating between long term and short term performance in the aforementioned studies. Especially since exploration is more critical for long term performance, whereas exploitation is beneficial on the short term.

Previously conducted studies on the performance implications of exploration and exploitation received criticism, and there is still no general consensus on how they relate to each other. However, the statement by March (1991) that ‘some kind of balance between the two is required’, still holds. It is, therefore, safe to assume that an excess of either exploration or exploitation is harmful for the organizations performance.
The Relation between Exploration and Exploitation

There are two theories that explain how exploration and exploitation relate to each other. As two ends of a continuum, or as two different and orthogonal aspects of an organization’s behavior (Gupta et al., 2006) (also see figure 2). For theories on balancing exploration and exploitation, it’s crucial whether they are treated as competing or as complementary. March (1991) was very clear on this; both compete for scarce resources and both are self reinforcing which leads to one driving the other out. Also, the two require very different organizational routines and mindsets. This argues for exploration and exploitation being two ends of one continuum.

There are, however, some counter arguments to this, like the assumption that some resources could theoretically be infinite such as knowledge or access to external resources (Gupta et al., 2006). Katila & Ahuja (2002) add a second dimension to this theory; they use Search Depth to describe the extent to which a firm reuses existing knowledge, and Search Scope to define the extent to which firms explore new knowledge. They argue that exploitation is also important for the creation of new knowledge; it leads to combining existing knowledge to generate new solutions (Schumpeter, 1934). This argues for exploration and exploitation to be orthogonal, or complementary.

Gupta et al. (2006) argue that the continuous or orthogonal operationalization is valid under different circumstances. The scarcer the available resources, the more likely the two are mutually exclusive. The level of the analysis also matters; in large firms, the two can be complementary but on an individual level it is more likely to be mutually exclusive. The substantial differences in routines between exploration and exploitation will generally make it very difficult for an individual to excel at both.

This study will treat exploration and exploitation as being two ends of a continuum and assumes they both compete for scarce resources. Since this study investigates the failure trap, defined by March (1991) as a situation where failing exploration drains resources, this definitions is most suitable.

Balancing the strategies

The need for a balance in the amount of exploration and exploitation is something most scholars agree on. However there still is discussion on how to successfully create such a balance. Two strategies for maintaining balance, are proposed; with the first strategy being ‘ambidexterity’, whereas the other is a ‘punctuated equilibrium’ (Gupta et al., 2006).
Ambidexterity
Ambidexterity can be defined as the synchronous pursuit of both exploration and exploitation, and finding an optimal balance between the two (Gupta et al., 2006). The logic for pursuing ambidexterity is that exploration drives on experimenting, while process management (or exploitation processes) tends to drive out experimentation. Exploitation processes must therefore be prevented to migrate into exploratory subunits. Conversely, exploitation subunits succeed by reducing variability and maximizing efficiency; ideally associated with process management (Benner & Tushman, 2003).

Conducting both explorative and exploitative behavior in an organization can be achieved by either pursuing structural or contextual ambidexterity (Birkinshaw & Gibson, 2004). In contextual ambidextrous organizations, all levels of the organization maintain both activities simultaneously. So a balance has to be found on an individual level. A downside of this method are the contradictions that arise within an organizational unit. Contextual ambidexterity can be found in companies like Google or 3M, where individuals get resources to individually pursue both exploration and exploitation (Steiber & Alänge, 2013).

Structural ambidextrous organizations make a distinction on an organizational level; both exploration and exploitation are pursued simultaneously but in separate business units. A challenge that arises from this structure is the difficulty of coordination across different organizational units. With this structure, the contradictions will remain on the top management level, since they still have to manage both exploration and exploitation. A good example of a company that pursued structural ambidexterity was Bell Labs, a pure research facility owned by AT&T (Juster, 1992). According to Birkinshaw & Gibson (2004), both structural and contextual ambidexterity is complementary; structural separation can be highly beneficial but only temporary. New initiatives need the space and resources to get started, but should be integrated into the mainstream organization as soon as possible.

Lavie et al. (2010) state similar findings; however, they acknowledge four ways of integrating both exploration and exploitation into the organization. The first, contextual ambidexterity, and second, organizational separation (= structural ambidexterity) are similar to the definitions given by Birkinshaw & Gibson (2004). They also define domain separation, which assumes explorative and exploitative activities can be carried out over multiple domains (i.e. with alliances). This way they do not have to reconcile balance within each domain as long as the overall balance is maintained over the domains. A downside here is the challenge of identifying applicable domains and coordinating over all domains. Last, they define temporal separation, referring to distinct organizational units that either explore or exploit. It involves cycles of exploration and exploitation during which an organization focuses primarily on one. A difficulty here is managing the transitions between exploration and exploitation and possible inertial forces that can distort that process. This method is also known as punctuated equilibrium (Burgelman, 2002).

Punctuated Equilibrium
The strategy of a punctuated equilibrium refers to temporal differentiation between exploration and exploitation and suggests that cycling through periods of either one is more viable than pursuing both at the same time (Gupta et al., 2006). Advocating for this strategy is Burgelman (2002), who states that
perhaps series of discrete periods, focused on maximally exploiting available opportunities, is preferred for preparing the ground for future growth opportunities. The model describes organizational transformation through cycles of convergence and upheaval where technology evolves over longer periods of environmental stability (exploitation), and short radical breakthroughs (exploration) (Tushman, Newman, & Romanelli, 1986). Because the separation is made in time, at different moments the organization is either pursuing exploitation or exploration. So when the balance is not optimal it is more likely that organizations engage in excesses of pursuing either exploration or exploitation, compared to organizations that follow an ambidextrous strategy.

Whether punctuated equilibrium is preferred over ambidexterity depends on several arguments (Gupta et al., 2006). If an analysis is conducted on the individual level, and exploration and exploitation are seen as two ends of a continuum, punctuated equilibrium is the suitable mechanism for balancing. This is because an individual is unlikely to excel at both, and the difference in routines makes it difficult for an individual to do both at the same time. When analyzing on a larger firm-wide scale and exploration and exploitation are seen as orthogonal, ambidexterity is the preferred strategy; the orthogonal theory states that both exploration and exploitation are complementary, thus needing both. These arguments are not mutually exclusive; both can be present in an organizational unit. Such a unit can pursue both exploration and exploitation, but the individuals or subsystems change over time as defined by punctuated equilibrium.

Summarizing; whether ambidexterity or a punctuated equilibrium strategy is preferred, depends on the context (Gupta et al., 2006). Since the main interest in this review is in the failure trap phenomenon, it will not go into depth about either of the two balancing strategies. Both strategies, being very different in nature, agree that excessive pursuance of either exploration or exploitation can be detrimental for an organizations performance. However, since this study has its focus on how top management directs its company as a whole; the ambidexterity approach seems more suitable.

**Consequences of imbalance**
As mentioned before in this review, an appropriate balance between exploration and exploitation is a primary factor in organizational survival and prosperity (March, 1991). Organizations that fail to find a suitable balance are likely to fall into dynamics of accelerating either exploration or exploitation, to at some point one driving out the other (Levinthal & March, 1993).

**The Success Trap**
The more common dynamic for an organization to get trapped in, is engaging in excessive exploitation. This phenomenon, where organizations get trapped in a situation where exploitation drives out exploration, is defined by Levinthal & March (1993) as the success trap or by some (Luzon & Pasola, 2011, J. H. Moore & Kraatz, 2011) as the competence trap. A given explanation for this trap is that established firms do not want to make their own products obsolete (Levinthal & March, 1993). Also, as March (1991) already elaborated on, exploration is a riskier mechanism due to its less certain returns, and success being more remote in time. Third, common incentive systems help with the enabling of excessive exploitation; Birkinshaw & Gibson (2004) defined the ‘burnout context’, wherein people are focused on high turnovers and are rewarded with a personal and annual bonus upon achieving
individual targets. Therefore employees focus on their own short-term targets and tend to forget what’s best for the organization. Typically this performs well for a limited amount of time. In a company with said incentives obviously the exploitation strategy is most likely preferred.

If the management of an organization is myopic for the impending danger of these dynamics, they will probably not notice it until it is too late (Levinthal & March, 1993). So making management aware of the success trap phenomenon could contribute in lowering chances for organizations to get trapped in it. In some situations however, management is (fully) aware of the need for exploration but somehow still fails to initiate explorative activities. Walrave et al. (2011) described that the interplay between top management, board members, and exploration – exploitation activities, can result in the success trap. The specific dynamics explain the process of how organizations get into a success trap; external pressure to exploit (i.e. from shareholders) keeps management from amplifying exploration even though they are aware of its need. They coined this ‘the suppression process’.

The eventual problem with this dynamic is that only focusing on exploitation will at some point lead to obsolescence (Levinthal & March, 1993); the competition that does engage in exploration will at some point surpass organizations that focus primarily on exploitation. Eventually, without the generation of new opportunities that the organization can later exploit on, the organization becomes completely caught in the success trap.

**The Failure Trap**
The opposite of the success trap is the failure trap. As defined by Levinthal & March (1993), it is a situation where exploration drives out exploitation. It is accompanied by frenzies of experimentation, change, innovation and lots of failure, which leads to more exploration, and so on. It places a continuous drain on resources without immediate financial reward. Also, organizations that concentrate on exploration tend to suffer from a lack of efficiency (because there is no experience with the exploitation aspects of business, since exploration implies at least knowledge new to the company) which will hinder its competitiveness (Luzon & Pasola, 2011).

Arrived at the main subject of this study, the failure trap, it can be safely concluded that the consequences of a failure trap are undesirable for an organization. In the process of answering the research question, the current knowledge on the subject of the failure trap is first addressed.

**(Lack of) knowledge on the matter**
The first thing that was noted is the lack of knowledge about the failure trap; specifically the lack of knowledge on the process behind the phenomenon. No literature has its main focus on the failure trap; they only mention this trap as part of bigger organizational processes. Also, while most authors seem to agree on the existence of the failure trap and the associated risks, all remain vague on how organizations actually get trapped:

‘If organizations overemphasize the pursuit of new alternatives and ignore their own capabilities, they can end up in an exploration (or failure) trap’ (Baumann & Martignoni, 2011, p. 397).

‘Over-reliance on exploration can lead to a “failure trap,” …’ (Su, Li, Yang, & Li, 2011, p. 700)
‘Therefore, focusing solely on exploration can be similarly detrimental for the firm locking it into a cycle in which ‘failure leads to search and change which leads to failure which leads to more search, and so on’ (Uotila et al., 2009, p. 223)

‘Exploration often leads to failure, which in turn promotes the search for even newer ideas and thus more exploration, thereby creating a “failure trap.”‘ (Gupta et al., 2006, p. 695)

‘Too great reliance on exploration without complementary exploitation may lead to a ‘failure trap’ (Liu, Luo, & Huang, 2011, p. 530)

These are just a few quotes from all articles that mention the failure trap. It seems that at this point the only thing all authors agree on is that it ‘can’ or ‘may’ happen at some point.

Authors also seem to have different views on how to define a failure trap in an actual situation. Take the Polaroid case; used by Liu (2006) to explain the failure trap. They note that Polaroid succeeded in out-innovating the competition, but then turned this policy into an obsession. They began to concentrate only on technological innovation, no matter the cost or the customers need. This led to the point where Polaroid was unable to derive any benefits from its new innovations, eventually leading to its bankruptcy. From this point of view, it seems like an exemplar case for an actual failure trap unfolding; however Tripsas & Gavetti (2000) use the same Polaroid case for explaining the success trap. In their article they mention Polaroid’s successful razor/blade business model, where money was made on the software (film) and not the hardware (cameras). Polaroid clung to this proven strategy up to a point where it became obsolete (the arrival of digital imaging). This led to the point where Polaroid was surpassed by competition and was unable to catch up, leading to its bankruptcy. From this point of view, a case of the success trap.

At first this might seem very contradictory; the same case used as exemplar to explain two opposite phenomenon, the failure trap and the success trap. There is however a big difference between the points of view taken; the view of Liu (2006) is on a product level, which, in the case of Polaroid, was very innovative and ahead of the competition. The point of view taken by Tripsas & Gavetti (2000), however, is about the business model of Polaroid, in which they were conservative and exploited it up to a point it became obsolete.

This contradiction shows the lack of knowledge about the effect of the failure trap; if an author labels the failure trap as the mechanism in a specific situation that led to bankruptcy, but only looked at one level of the organization, many other factors might have been much more influential. For example, the Polaroid case; it might have been that the exploitation of the business model had more influence on the bankruptcy than the exploration obsession.

It is safe to assume that the emergence of the failure trap differs for each specific (sub) organization / situation, and the point at which a (sub) organization falls into the failure trap is not to be set in stone. Yet, more insight in the specific processes that underlie the failure trap could help managers to proactively adapt the company’s course.
Current knowledge on the matter
The failure trap is a phenomenon any manager wants to avoid since it poses a real threat. But to avoid it, management has to be aware of the different factors and processes that drive a company into the failure trap, and as such be able to adjust these factors to prevent the company from getting caught in such a trap. While there is no literature that investigates these determinants, many possible explanations, propositions and hypotheses, however, are scattered over the available literature. Since this research focuses on internal managerial forces, for reasons as described, only those will be presented.

Innovation Extremeness -- How the top management of an organization handles its exploratory behavior influences whether or not the company falls into the failure trap. A determinant could be the ‘extremeness’ of the exploration process (Moore & Kraatz, 2011). Organizations have a higher chance to get caught in the failure trap when they stray too far from its existing competencies and routines. It does sound plausible that an electronics manufacturer is more likely to be successful in radical technological exploration than, for instance, a bakery store. However, Levinthal & March (1993) argue that companies that do not conduct radical innovation to some extent, thus not ‘straying far from its existing competencies and routines’, could end up in a success trap. Since this research focuses on the failure trap and ‘going too extreme’ can increase the possibility to enter a failure trap, we will use the findings of Moore & Kraatz (2011).

First-Mover Effect -- If a company’s management has a first-mover strategy and is willing to invest large amounts in exploration to be the first on the market, that organization has a higher chance of getting into the failure trap (Liu, 2006). Whereas management that focuses on efficiency and is conservative is more likely to get into a success trap. A company that has mastered the first mover strategy will most likely be capable of identifying new possibilities and change structures quickly. The pursuit of this strategy (the learning process towards mastering it), however, leads to rigidity and unresponsiveness to further changes, which could push an organization into a failure trap (Liu, 2006).

Risk-Taker Effect -- Liu (2006) also proposes the degree of risk-taking to be related to the possibility an organization gets caught in the failure trap. They define this as the willingness to commit high amounts of resources to projects that also have a very high cost of failure. In response to the accompanied pressure of risk-taking, managers are tempted by, and often succumb to excessive exploration. These managers will make more and more uncertain decisions that will rarely generate long term growth. This could also be related to the ‘extremeness’ of the innovation; they will stray further and further away from the company’s current competencies in search of success.

Escalation of Commitment -- (Sub) organizations trapped in cycles of failure continue to conduct their exploratory behavior while it keeps failing over and over. One could argue that this phenomenon is a case of escalation of commitment. Sleesman, Conlon, McNamara, & Miles (2012) describe escalation of commitment as the tendency for decision makers to maintain commitment to losing courses of action, even while receiving negative information. Some determinants causing this stubborn behavior are invested time, threat to ego, and sunk costs. So translated to strategic exploration decisions, it might be that the determinants affecting escalation of commitment also partly trigger the failure trap if a
company invested heavily on a R&D department. Management might be afraid of losing their image as a highly innovative company, or has simply set its mind to an explorative course. This management urge seems similar to the findings of Olson, van Bever, & Verry (2008), who link growth stalls in successful companies partly to management abandoning their core business prematurely to pursue new markets. When their core business keeps lagging behind, the need for outside-the-core becomes urgent. This process could then also drive the strategic focus, degree of risk-taking and/or the ‘extremeness’ of the innovation upwards.

**Aspiration Adjustment Inertia** -- Possibly related to the escalation of commitment issue, or even a special case of it, is the fact that managements aspirations adjust downward more slowly than they adjust upward. Also, they have a consistent optimistic bias (Lant, 1992). This is partly caused by the believe in ‘post-decision control’; managers tend to believe they can influence the outcomes towards their desires. Adjusting aspirations downwards would create a feeling of giving up. So when management has set the desired level of exploration to high to begin with, it will only slowly be turned down. If this inertia proves to be too much, it might contribute to the company falling in a failure trap.

**Innovation Impatience Effect** -- Next, innovation success is partly a function of an organizations experience with the new idea. Eventual successful innovations are likely to perform poorly at first until experience in using them has been accumulated (Levinthal & March, 1993). So the organizations expectations are generally not met in the short term, due to the fact that a longer timeframe is needed to see the results of new initiatives. Consequently, these initiatives are possibly abandoned to move the focus to other avenues (Luzon & Pasola, 2011, March, 2003). So it could be that management does sometimes lack the patience to wait for the results of new products, and unjustly reject them. This does however seem contradictory to the escalation of commitment argument, but it might be that management is committed to firm-wide exploration and sees individual innovative initiatives that do not pay-off quick enough as threats to the ‘bigger picture’.

**Absorptive Capacity Effect** -- As opposed to waiting longer, companies can also try to learn faster. The speed at which an organization is able to assess value of external knowledge, internalize, and apply it, is defined as its absorptive capacity (Lavie et al., 2010). This is somewhat similar to what Tripsas & Gavetti (2000) found. They found empirical evidence that new technology, requiring the mastery of an entirely new scientific discipline, is more likely to fail in established firms due to inertia. So the absorptive capacity of a company seems to be positively related to the speed at which organizations are able to capitalize on new ideas and therefore might reduce the chances for organizations to get caught in a failure trap.

**Strategy Incompatibility** -- Another factor that may influence the manifestation of the failure trap is conservatism in other levels of the organization. Looking at the Polaroid case again (see p. 8), it was noted that Polaroid got caught in a failure trap on a product level (Liu, 2006), but experienced a success trap on a strategic level (Tripsas & Gavetti, 2000). So no matter how much potential an organizations new products have, if they are incompatible with the business strategy, failure is likely. A modern day example of this phenomenon is Nokia; as of December 2012, 28% of their total workforce was working in R&D, although the share price of Nokia is decreasing since 2007 (Nokia Annual Report 2012). Before
2007 Nokia successfully differentiated themselves from the competition with their user friendly Symbian interface, but after the arrival of iOs (Apple) and Android (Google) they clung to their old business model of differentiation through interface. It took Nokia until 2010 to realize their Symbian interface was unable to compete with iOs and Android and caused them to switch to Windows Phone interface. Today, Nokia is the only manufacturer that ships their smart phones exclusively with Windows Phone, and their old business model of differentiating themselves through interface still seems intact. Nokia's share price, however, is still declining. So the radical innovation of a completely new interface (Windows Phone) appeared to be incompatible with the conservative business strategy, and therefore did not turn the tide.

So while at first sight it doesn’t seem much is known about the dynamics and relations behind the failure trap phenomena, there actually are some quite valuable propositions and possible variables scattered over different articles. If these factors appear to be able to distort the process of finding a balance between exploration and exploitation, more insight can be gained into the process behind the failure trap.

**Method**

To establish the most suitable method for testing what effects and underlying relations the possible causes have in triggering the failure trap, a choice has to be made between a variance model and a process model (Van de Ven, 2007).

A variance model, underlying a so called ‘what’ research question, explains variation in the outcome criteria (dependent variables), statistically caused by the input factors (independent variables). It gives the antecedents or consequences of the issue. A process model on the other hand, underlying a so called ‘how’ research question, examines an observed sequence of events or an underlying generative mechanism that causes events to happen in the real world. It shows how issues emerge, develop, grow, and terminate over time.

First of all, the outcome is not the most important thing; after all, most scholars agree on the existence of the failure trap. How organizations get caught in it is the question that current literature is unable to answer. Also, the failure trap is a dynamic phenomenon with a reinforcing nature (Levinthal & March, 1993), and the determinants might act different over time or when coupled with other forces. Therefore the process modeling method seems like the most suitable method for testing the propositions.

The failure trap and its dynamics will be tested using system dynamics modeling. System dynamics is a tool, used for understanding the behavior of complex systems and how they change over time. System thinking is suitable for explaining the mutual interactions of different variables of which the outcome is hard to predict by logic and can provide insight in the way these processes evolve. Given the reinforcing nature of the failure trap, and the fact that the purpose of this research it to develop an insight on how a company gets pulled into such a trap, system dynamic modeling is a good fit. This is also confirmed by the study of Walrave et al. (2011), who created a process theory of the dynamics behind the success trap.
**Data Collection**

The research strategy is a case study, using available data and conducting an interview with top management on the matter of the failure trap. As mentioned by Eisenhardt (1989), a case study is a useful tool that focuses on understanding the present dynamics within a single setting. Given the timeframe in which this research is to be completed a case study on one company is conducted. Since there are not many real life examples of organizations that have been caught in the failure trap (on the Polaroid case, for example, is no consensus whether it even was the failure trap unfolding, see page 8), generating a system dynamic model representing such a firm is, therefore, unrealistic.

As a solution to this, the model will be based on a firm that could theoretically fall into the failure trap. Therefore, it should conduct its own exploration activities, otherwise the failure trap could, by definition, not exist. The organization should also preferably be an established player in its market that is not likely to go bankrupt easily. Since this research aims at better understanding underlying processes, modeling a start-up company that could go bankrupt after one failed innovation doesn’t fit.

Data gathered through the case study is used to build a system dynamics model which represents the processes that determine the balance between exploration and exploitation. Next, one factor derived from theory will be introduced to the model to see how it influences this balance and if it is capable of triggering the failure trap. Because the process is simulated, it is not necessary for the company the case study is conducted on to actually experience, or having experienced, the failure trap.

The case study will also be used to gather expert input on the matter of the failure trap. The possible factors derived from theory will be evaluated, from a practical point of view, on its impact in triggering a failure trap. This will contribute in the selection of one factor that will be introduced into the model. The selection will also be based on the factors fit with the model, and how plausible it is in representing a real life situation.

**Case Study**

After formulating several different managerial forces that could trigger the failure trap, a real-world case is being explored to create a working model usable for testing those forces. Also, expert input on the failure trap phenomenon can lead to new insights. An interview was conducted with the former Global Technology manager, and current Senior Director Interoperability and Standardization at one of the world’s largest manufacturers of lighting. The semi-structured interview was used to gain insight in three area’s; data that can be used to create a base-model, additional expert input on the failure trap that available theory perhaps does not cover, and expert opinion on the found theory and its actual impact in practice. The studied company was chosen because it fits the company profile as mentioned above, not because it has experienced, or is experiencing the failure trap. For building the system dynamics model, based on a real company, only
the constants and initial values are important so they represent a realistic situation. Theoretical factors are then added to this model to test their effect.

The base-model
To get the base model to resemble practice, several numbers were gathered from the company. Note that the company was reluctant to give financial information not available in the annual report, so some values are rough estimates given by the interviewed expert. First, a clear separation was made between the exploration-, and exploitation-related research conducted at the company. The LED-division was taken to resemble exploratory research since LED is still in the introduction stage of its life cycle. See figure 3 for a given estimation of the LED life cycle, estimated by the interviewed expert.

The three other divisions; traditional lighting, fluorescence lighting, and halogen lighting, were taken to resemble exploitative research. Resources put in these three fields are only spent on cost reduction, and the technology is in its decline phase.

Further data and estimates on several variables used in the base model are represented in table 1. The numbers are based on the 2012 annual report, and will represent the model on t = 0. Numbers used in the R&D Rate, and Value Decay variables are based on Haitz Law. This is a forecast similar to Moore’s Law; predicting that every decade, the cost per lumen decreases by a factor of ten, and the amount of light generated increases by a factor twenty.

<table>
<thead>
<tr>
<th>Table 1 – Variable</th>
<th>Model Reference</th>
<th>Value (2012)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revenue</td>
<td>Exploitation PV</td>
<td>8.442 million</td>
</tr>
<tr>
<td>R&amp;D Expenses</td>
<td>R&amp;D Rate</td>
<td>453 million, or 5.3% of revenue</td>
</tr>
<tr>
<td>Resources on Exploration (LED)</td>
<td>Exploit -&gt; Explore Balance</td>
<td>80% *</td>
</tr>
<tr>
<td>Resources on Exploitation (rest)</td>
<td>Exploit -&gt; Explore Balance</td>
<td>20% *</td>
</tr>
<tr>
<td>New Ideas per Period</td>
<td>R&amp;D Rate</td>
<td>1 year</td>
</tr>
<tr>
<td>Value Decay Rate</td>
<td>Value Decay</td>
<td>Factor 0.5 each year</td>
</tr>
<tr>
<td>Knowledge Decay Rate</td>
<td>Knowledge Decay</td>
<td>1 Year *</td>
</tr>
</tbody>
</table>

*Expert Estimate

The expert interview resulted in two new possible factors that can result in potentially successful innovation failing nonetheless. These factors, when consistently present in the company, might contribute to organizations getting caught in the failure trap.

Cold Feet Effect -- The first factor is similar to the Innovation Impatience Effect, in a way that it also revolves around innovations being rejected in an early stage. However, where the innovations rejected by innovation impatience are already on the market and are being pulled out too early, this factor takes place in the development process. It was referred to as ‘getting cold feet’, where management decided at some point in the development process that the innovation was not such a good idea after all, seemingly only based on the feeling of the top management. The expert acknowledged that he had experienced several occasions where a product was pulled out of its development, while many others were still convinced about its potential. In a retrospect, it is impossible to tell if the termination of a development process was unjust; after all a launch has never taken place and the market was never able
to adopt the innovation. It is however very hard to generalize the Cold Feet Effect, since it can occur for many reasons; from the change in top management positions, to a manager ‘having a bad day’.

Ecosystem Incompatibility -- Another factor that could lead to innovations with high potential failing nonetheless, is the innovations incompatibility with the required ecosystem. For example, say that a manufacturer would launch a very cheap and energy friendly source of lighting, but to use it, it would require one to rewire the whole building. The innovation would be incompatible with the environment and therefore would likely fail if launched now. This factor is mainly influenced by the ecosystem and it is therefore not a direct negative influence from top management.

The Innovation Impatience Factor
As mentioned at the introduction of this article, only one of the possible factors that could get an organization caught in the failure trap will be introduced into the system dynamics model. Every factor derived from theory stands on its own and therefore does not need interaction with other factors to be implemented in the model. When testing multiple factors, each one has to be implemented in a separate model to avoid unexpected interaction that can bias the outcome. It should be noted, however, that in a real situation it is likely that multiple factors are present. Studying the interaction of factors could therefore be very valuable to understanding the process underlying the failure trap. However, since no previous research is conducted on the individual factors and their relation to the failure trap, this study will look at the individual factors. This research will therefore limit itself to the creation of only one model. The variable that will be introduced to the model to inspect its influence on the failure trap is the Innovation Impatience Effect. The reason for the selection of this variable follows from the assessment of all previously mentioned factors:

Innovation Extremeness -- This factor, as derived from Moore & Kraatz (2011), should not really be an issue in modern companies. Nowadays organizations already hire a lot of knowledge and/or capacity from outside the company so theoretically anyone could make everything. If management knows the market well enough, they can go as extreme as they feel the market demands, even if it is more out of the companies comfort zone. Also, Levinthal & March (1993) state that conducting radical innovation is actually a good thing. Therefore this factor will possibly only have effect in extreme situations that are not very likely in established multinationals.

First-Mover Effect – Theorized by Liu (2006), and possibly a factor in triggering the failure trap. However, in volatile environments multinationals are in, they have to do both. Trying to enter the market quickly, and next, immediately starting with cost reduction programs to make sure competition (e.g. Chinese manufacturers) do not copy the technology and lower the prices to a level where other companies cannot compete. So this effect is possibly more a precondition than an effect.

Risk-Taker Effect – An effect that has negative consequences for almost everything; taking more and more risk will at some point go wrong. It is therefore likely this will also negatively impact the R&D process, leading to more risk-taking behavior and so on Liu (2006). On the other hand, when selecting
only one variable to implement in the model, it doesn’t seem to be the most interesting one since its effect is so likely.

**Escalation of Commitment** -- A possibly very influential factor in traditional organizations that is, however, easily solved by an effective stage-gate process. Since most modern-day organization have implemented such a process this factor is unlikely to still have a big influence. It is also unlikely that this factor can be easily implemented in the model. For instance, more knowledge on the effect of stage-gate processes on this factor might be needed, which is outside the scope of this project.

**Aspiration Adjustment Inertia** -- Inertia will always be an issue in organizations, hence also in respect to the failure trap (Lant, 1992). Since system dynamic modeling incorporates delays between most of the aspects in the model, this factor is already implemented in the base model. It is, however, hard to draw general conclusions on the impact of delays since they are specific for each model.

**Innovation Impatience Effect** – Interesting factor, stated by March (2003), and Luzon & Pasola (2011), since it is a similar issue as the one described in the ‘crossing the chasm’ theory, where a small dip in the growth stage is unjustly perceived as failure (G. A. Moore, 1991). While the ‘crossing the chasm’ theory had a significant impact on high-tech entrepreneurship, no articles link similar effect to the failure trap. This factor also seems easily implemented in the base model since it directly impacts the commercialization rate and stands on its own as a factor.

**Absorptive Capacity Effect** – Possibly an important factor for successfully introducing innovations to the market. However, it consists of the ability to assess value of external knowledge, internalize, and apply it (Lavie et al., 2010) which seems very difficult to quantify. At this point, it is therefore impossible to implement this factor into the model in a scientifically supported way. More research on absorptive capacity, and how it affects innovation should be conducted, which is outside the scope of this study.

**Strategy Incompatibility** – Possibly one of the most important factors, derived from Liu (2006), and Tripsas & Gavetti (2000). This effect might have contributed to the downfall of Polaroid (see p. 7 and 9). To embed this effect in a system dynamic model, however, more knowledge is needed. This effect comprises two different processes; the new technology flow, and the business strategy flow. For model validity, more information is needed on how these flows interact, which, due to time constraints, is outside the scope of this study.

**Model Description**

When building a theoretical model, several assumptions have to be made. First of all, the model only contains internal variables. Influence of shareholders, effects of marketing efforts, etc. are outside the scope of this model. This is with the exception of value and knowledge decay, driven by a fixed, oscillating variable depicting market volatility and market competitiveness. Without value and knowledge decay balancing the portfolio value, the model would exponentially grow, producing an unrealistic outcome. Furthermore, the model assumes the ambidexterity level is based on prior performance; if targets are not met, the strategy is adjusted accordingly. The perceived portfolio value, being either the exploration or exploitation portfolio value, lagging most behind its desired portfolio
value, will receive an increasing amount of resources at the expense of the other. Final assumption is that each innovation generated by R&D has the same potential, and is capable of generating the same return on investment as each other innovation. In other words, each idea is as good as the other. This assumption is made because the factors found, including the *Innovation Impatience Effect*, cause potentially successful innovations to not reach their potential after all. The impatience effect is far less relevant for innovations with very little potential since they are likely to fail anyway. Other factors that possibly influence the success rate of innovations, such as the quality of market research, are beyond the scope of this study.

Next, a comprehensive description of the base model and the introduced *Innovation Impatience Effect* is given. A detailed description is available in the appendix. The model, as can be seen in figure 4, consists of four main stocks; the resources available for either the creation of knowledge (exploration) or value (exploitation), the exploration portfolio value, the exploitation portfolio value, and the ambidexterity level which determines the distribution of resources between the two value stocks.

The primary loop in the model is the reinforcing *Growth Loop (red)*; resources are allocated to R&D to generate knowledge, that knowledge is translated into value, which on its turn generates resources for more knowledge creation, and so on. This ongoing process is what enables organizations to grow and is acknowledged by science ever since Schumpeter (1934) has made mention of it. External forces, however, are responsible for this process not being able to grow indefinitely. The exploration portfolio value lowers from the effect of knowledge decay, caused by market volatility. For instance, new technological breakthroughs can lead to quick depletion of all potentially valuable knowledge. The same goes for the exploitation portfolio value; the competitiveness of the market influences the speed at which an organization's portfolio devalues. For instance, if the competition lowers its prices you would have to either go along with these price drops or upgrade your products to justify the higher pricing. Both options are at the cost of your current portfolio value. These market forces are modeled as oscillating functions with periods of higher and lower impact.

The stocks representing exploration and exploitation portfolio value are both accompanied by two related stocks; the perceived value and the desired value. External forces (market volatility and market dynamism) influence the portfolio values, which on their turn determine the perceived values with a delay. Whether these perceived values go up or down determine, also with a delay, if the desired values go up or down. The misfit between these perceived and desired values influence the ambidexterity level; either lowering it in favor of exploration, or increasing it in favor of exploitation. This process is represented by the balancing *Exploration Push Loop (brown)* and the reinforcing *Exploitation Push Loop (purple)*.

The change in ambidexterity level is based on two ratios. The first being based on the difference between the perceived and the desired value of the exploration portfolio (*PDeR Ratio*), the second on the perceived and the desired value of the exploitation portfolio (*PDeI Ratio*). These ratios are compared, where a high *PDeI Ratio* accompanied by a low *PDeR value* lowers the ambidexterity level towards exploration, since a healthy exploitation portfolio will induce more R&D. A low *PDeI Ratio* and a high *PDeR Ratio* increases the ambidexterity level, since having many ideas but not much value actually
in the market, will put pressure on the management to commercialize the ideas. Thus an ambidexterity level of 1 represents full exploitation and a level of 0 represents full exploration. The ambidexterity level influences the R&D rate through a Resource Reinvestment variable, where more focus on exploration means more generated resources being directly reinvested into R&D. The commercialization rate is influenced through the Return on Investment variable, where more focus on exploitation increases the RoI made on the company’s commercialized knowledge. This could be thought of as allocating more resources into marketing or the creation of line-extending products. Both the Resource Reinvestment and the Return on Investment variable follow a logarithmic curve; at higher values, more effort is needed to obtain increasingly smaller results.

The Innovation Impatience Effect is introduced into the model using a stock representing the impatience level. When innovations are abandoned due to not reaching their full potential on a short term (Luzon & Pasola, 2011, March, 2003), it is safe to assume that the chance of abandonment increases if the time given to new innovations to reach their potential decreases. When a company is underperforming, it is likely the need for short term success grows; either by increasing pressure from stakeholders or by depletion of resources. Therefore, in the model it is assumed that the firms performance influences the level of impatience that management has with its innovations. If this level decreases, management becomes more impatient for their innovations to fully reach their potential, and more innovations will be unjustly pulled from the market. Such withdrawal means that the resources spend to develop the innovation and bring it to the market are, at least partially, lost. It can therefore be assumed that an increasing amount of unjustly withdrawn innovations decreases the overall success rate of the organizations innovations. This decrease means the overall return on investment on R&D of the company is lower compared to a state where more innovations were given the chance to become profitable. These assumptions are modeled through the reinforcing Impatience Loop (green). This loop is driven by the PDEi Ratio; when it increases, meaning the gap between the desired and perceived portfolio value is increasing with the perceived value being the lower, management becomes more impatient with their innovation on the market. This impatience directly influences the RoI; an increase in unjustly rejected innovations will also lead to a decrease in the R&D RoI. A lower RoI leads to a lower exploitation portfolio, further increasing the PDEi Ratio.
Figure 4: The Model (simplified)
Simulating the Model
With the model completed, different scenario’s can be tested. First, a reference run is conducted under ideal circumstances with only the characteristics as stated in the detailed model description (appendix, table 2). Next, the external influences of market competitiveness and dynamism are added to the model. Finally, the innovation impatience effect, which can theoretically push organizations into a failure trap, is added to see its influence.

Simulating Under Ideal Circumstances
Without any forces that negatively influence the process, the modeled company can freely grow. The resources over time are stated in figure 5. The accompanied ambidexterity level in this simulation stabilizes at an exploration / exploitation ratio of 46 / 54 as can be seen in figure 6.

In both the exploration-, and exploitation portfolio value graphs (figure 7, and 8), a decline can be seen in the first few years, both followed by a stable growth. This decline is caused by the value and knowledge decrease rates, which immediately start to lower the portfolio values. The development delays, as well as the ambidexterity level adjustment delays, take some time to refill those values. After finding an optimal state, the company can begin to make a profit.

Simulating in a Dynamic Market
The next step in testing the model is adding external market influences. Two factors, Market Volatility and Market Competitiveness are added. Volatility influences the knowledge decay rate; in a very dynamic (technical) market where breakthrough innovation can quickly follow each other, knowledge can quickly become obsolete. The standard decay time for knowledge is set to 24 months, but the volatility variable influences this number up to a 70% increase or decrease in a cycle of 48 months (see the appendix, figure 13).
Market Competitiveness influences the decay of value; when the competition becomes more intense and companies start to lower prices, or quickly make product line extensions, the value of the current product portfolio lowers. The standard value decay time is set to 36 months, but the influence of competitiveness leads to an increase or decrease of up to 40% in a cycle of 96 months (see the appendix, figure 14).

The addition of market variables influences the company’s performance in a negative way, but it still manages to maintain growth. However, the growth is about 50% lower at the end of the simulation (see figure 5). The same goes for the Exploration PV and Exploitation PV; both about 75% lower (figure 7 and 8). Also interesting to see is that the ambidexterity level increases up to a (semi-) stable exploration / exploitation ratio of 20 / 80. So in a highly dynamic market, the company tends to increase their exploitation efforts. This can be explained by the model having a more volatile knowledge decay, compared to the value decay, making exploitation more lucrative. This effect is similar to what happens with the success trap; a company trying to maximize its performance prefers exploitation at the expense of exploration given its more certain returns and less risk (March, 1991).

Simulating with Innovation Impatience
Next, the Innovation Impatience Effect is added to the model. In theory, the impatience effect causes potentially successful innovation to be withdrawn from the market before they reach their full potential. In the simulation, this effect is created by innovation impatience influencing the return on investment on R&D. In a state with an increasing amount of unjust withdrawal of innovations from the market, the simulation also decreases the RoI. The severity of this effect is influenced by the difference between the perceived and the desired exploitation portfolio value; when this gap increases, and the desired value is bigger than the perceived value, the effect also increases. This effect can push the RoI below zero. This state resembles a company that is losing money on their R&D efforts. One can imagine such a situation where an organization conducts R&D while exceeding their budget, and then failing to make it profitable.
The effect of innovation impatience is tested with different delays; where 3 months proved to be the tipping point. This delay is defined as the speed at which management starts to unjustly withdraw innovation in a reaction to undesired differences between the desired and the perceived portfolio values (i.e. the lower the value, the bigger the negative impact).

As can be seen in figure 9, a delay of 3 months means management reacts too stressed to a period where the ambidexterity level is only decreasing to a stable optimum (roughly the period 96 – 144 months). This huge reduction of the ambidexterity level is caused by the PDEi Ratio (figure 10) climbing to its maximum; the point at which the difference between the desired and perceived value is the largest. In a normal situation (with impatience having no effect) this does not pose a problem, since it means that the desired value is too high and its accompanied adjustment delays too long. However, with the impatience level becoming an increasing influence, management starts withdrawing innovations that do not meet their expectations, lowering the RoI. With a lower RoI on innovation, the organization needs more innovations to generate the same resources, hence the lowering of the ambidexterity level towards exploration. With fewer resources available for exploitation the RoI is lowered even more, creating a reinforcing loop with fatal consequences. The effect on the resources can be seen in figure 11.

It takes the organization roughly 100 months to fully reorganize and return to its initial ambidexterity level (figure 9), but it then severely overshoots to full exploitation in an attempt to compensate. The failure trap, however, is already triggered by the rapid increase of exploration, and the organization’s resources continue to decrease.

The main reason why the company is unable to make itself profitable again is the RoI on R&D. The sudden change to full-out explorative behavior and the accompanied negligence of exploitation efforts lowered the RoI to a point where delays and the lack of resources make it impossible to turn it upwards again. This lack of resources is caused by the lowering towards full exploration. This decline caused too much loss in the exploitation portfolio value for it to support the increasing need for exploration due to the *Innovation Impatience Effect*. 
Discussion

The failure trap, a result of excessive exploration at the expense of exploitation, was first mentioned by Levinthal & March (1993) as a dynamic that could be harmful to organizations and should be avoided. Many authors acknowledge the existence of the failure trap and confirmed it could take place (Baumann & Martignoni, 2011, Uotila et al., 2009). It remained unclear, however, how such a trap actually manifests itself. What is the underlying process that gets the organization from excessive exploration to impending bankruptcy?

This study investigates the impact of top-managements impatience with innovations on the unfolding of the failure trap. Briefly proposed by March (2003) as an explanation of the failure trap, this study aims to gain a better understanding on if, and how, this effect can disrupt an organizations ambidexterity level, and how big its influence should be to be able to push an organization into the failure trap.

Before the results are discussed, it should be clear what to expect when looking for the failure trap. If we look at the concept of the failure trap, as defined by Levinthal & March (1993), it is a situation where exploration drives out exploitation. It is accompanied by frenzies of experimentation, change, innovation and lots of failure, which leads to more exploration, and so on. With the result that the organization is trapped in an endless cycle of failure and unrewarding change (Liu, 2006). This definition implies that a company caught in the failure trap conducts excessive exploration until it is bankrupt. However, this also implies that management is doing nothing to change this failing course, which seems unrealistic. Especially within large multinationals, having many stakeholders and more reserves compared to small companies, the full unfolding of the failure trap could take relatively long. It is hard to believe every stakeholder is so myopic, that they would pursue this failing course of excessive exploration until the end.

Next, take the definition of the word ‘trap’, as defined by the Webster’s Dictionary, which is ‘something by which one is caught unawares; and a situation from which it is impossible to escape’. This definition states it is impossible to escape from, meaning ‘no matter what you try’. It is therefore more likely that an organization caught in the failure trap, at the point where they notice being caught, will try and do everything in their power to get out. So what we would expect to see when the failure trap manifests itself are the following phases:

Run-Up Phase – Something causes a rapid increase in exploration efforts, accompanied by frenzies of experimentation, change, innovation and lots of failure, as defined by Levinthal & March (1993);

Trigger Phase – Beyond a certain tipping point, the failure trap is triggered with management still unaware;

Awareness Phase – After a certain period, caused by delays, management will become aware of the decline in performance and will try and do everything they can to stop this decline;

Terminal Phase – Despite their efforts, full decline is imminent.
Comparing the abovementioned phases with the simulation results, it can be concluded that, yes it is possible to push an organization into a failure trap. The phases are clearly visible in the simulation results with the influence of the Innovation Impatience Effect, as can be seen in figure 12. The simulation shows a ‘too stressed’ reaction to a difference between the perceived and the desired portfolio value (Run-Up Phase), and beyond a tipping point triggers a frenzy of exploration and failure (Trigger Phase). This lasts until management realizes the negative consequences and starts altering the strategy (Awareness Phase). This effort, however, is not able to turn the performance decline upwards again (Terminal Phase).

Looking at figure 12, it can be seen that at approximately t=230, the ambidexterity level rises, and stabilizes, on full exploitation. This resembles a state where exploitation drives out exploration, which is defined by Levinthal & March (1993) as the success trap. With the success trap being the opposite of the failure trap, this seems very contradictory to what was just labeled as the failure trap. Even more so since the ambidexterity level never came close to exclusively exploration, where it did go to full exploitation. This paradoxical situation, where the results look more like a success trap than a failure trap, can be explained by comparing the ambidexterity level to the resource level of the organization (figure 12). The sudden increase of exploration efforts at about t=130 is responsible for the fast decline of resources. Everything beyond that point, in the Awareness Phase, is an effort to turn the organization profitable again, which in this specific model means an overshoot towards full exploitation. The reason the simulated organization is moving towards bankruptcy is the excessive exploration at the cost of exploitation at t=130, not the exclusive exploitation in the final stage (beyond t=230).

This study contributes by being the first to visualize dynamics behind the failure trap and its effect on the organizations performance. This visualization raised the question, as mentioned above, why it isn’t actually an instance of a success trap instead of a failure trap, since the final phase of the simulation encompasses exclusively exploitation. For spectators that aren’t able to see the full process, but only the Terminal Phase of the organization, it is likely they will label it with the success trap. This brings up the question whether this isn’t the case in previous studies on the success trap; was it really a success trap, or the Terminal Phase of decline triggered by a failure trap? Also, it this situation possible the other way around; where a sudden increase in exploitation eventually leads to a Terminal Phase with exclusive exploration? Future research should be conducted on the relation between the success trap and the failure trap since they appear not to be mutually exclusive, as was already concluded from the Polaroid case being labeled as an instance of both traps (see p. 8).
In this model the tipping point for triggering the failure trap was found to be at a delay time of three months; starting to withdraw innovations when targets are not met within three months proved to be a too stressful reaction. The Innovation Impatience Effect also proved to be able to pull an organization into the failure trap on its own. However, a withdrawal-time of only three months is arguably unrealistic; given the time takes to get from an idea towards a fully developed product on the market, it is unlikely it will be withdrawn after only three months. While unrealistic, in less stable situations (i.e. less reserves, higher development costs, additional factors able to trigger the failure trap, etc.) the Innovation Impatience Effect could trigger the failure trap with a longer withdrawal-time. Also, when the Innovation Impatience Effect’s withdrawal-time is lessened to twelve months, a negative effect can still be seen on the resources compared to a situation where the Innovation Impatience Effect is not present (figure 11). With a twelve month delay resources stabilize around 650 million, so in this situation a failure trap does not apply. This dampened growth, however, proves that the Innovation Impatience Effect can still be harmful to the organization, even if it is not severe enough to actually trigger the failure trap.

It is likely that the failure trap in real situations is not triggered by only one force, but by a series of multiple forces causing the ambidexterity level to maintain low (inducing exploration) for an extended period. This could be internal factors, such as the Strategy Incompatibility (see p.10), or external factors such as competition speeding up the value decay. This, accompanied by the Innovation Impatience Effect, would possibly cause an even faster decline of the organization. While plausible, further research on other factors capable of triggering the failure trap, and how they interact, is needed to verify the hypotheses of faster decline.

**Implications**

Testing the implications and finding out what their influence is on the forming of the failure trap has both theoretical and practical implications. First of all, it can add to the theoretical discussion of the exploration versus exploitation debate. Exploration and exploitation have become consistent themes in literature on organizational learning, and most scholars agree that excesses of either one can lead to traps. However the ‘trap’ component itself has received less empirical scrutiny (Liu, 2006). This is in line with the findings from this study; not much is known about the specific processes driving organizations into the failure trap. This knowledge could help scholars create theoretical frameworks that better explain this phenomenon. Also, the literature that does exist approaches the failure trap in a top-down way; innovation includes both exploration and exploitation, overemphasizing either one possibly leads to a success trap or failure trap. If, however, the failure trap process could be explained on a smaller and more detailed level, ‘higher level’ phenomena like ambidexterity or the exploration vs. exploitation debate could be approached with a bottom-up approach that might give new insights there as well. For instance, the simulation proved that the Innovation Impatience Effect is capable of triggering a failure trap. This implies that the effect is capable of disrupting the ambidexterity balance, meaning the Innovation Impatience Effect might as well be of interest in the ambidexterity debate. Also, since the failure trap implies failure of innovations, the findings on the Innovation Impatience Effect also contributes to literature on innovation performance.
The practical implications could be to directly help practitioners in reducing the risk of their organization to get trapped into a dynamic of failure. For years scholars have been warning for the dangers of the failure trap (Levinthal & March, 1993, March, 2003, Uotila et al., 2009) but none gave managers specific directions on where to look and change course to help avoid getting trapped in one. Since there is no proposition on how to actually measure if a specific firm has achieved the most optimal balance between exploration and exploitation, this remains an abstract concept. Identifying the processes underlying a failure trap could help managers actually adjust their business strategy to avoid entrapment or improve innovation performance. More specifically, awareness of the four different phases that encompass the failure trap can help managers with identifying the failure trap in an early stage; the Run-Up Phase. Symptoms in this stage are increasing exploration efforts paired with a lower R&D RoI and an increasing pressure for short term success. The Run-Up Phase is the movement towards the tipping point actually triggering the failure trap (figure 12), thus if management is aware of the impending danger, it can still intervene and fend off the failure trap by finding a way to give promising innovations time to fully reach their potential.

This study examined one managerial force, the Innovation Impatience Effect, which showed to have at least a negative effect on the organizations performance and is capable triggering the failure trap phenomenon. So even when managers are not concerned with getting caught in a failure trap, the positive effect of avoiding innovation impatience is noteworthy.

Limitations and Future Research

The model created in this study showed that it is possible for an organization to get pulled into the failure trap using the Innovation Impatience Effect. The case is based on one real organization which could raise questions on generalizability. However, as can be seen in the figures on page 17 and 18, the model find its equilibrium at some point in time, that differs from the original values at t=0. Also, the dynamics at play are more important than the values at t=0. The sensitivity report (appendix, table 3) shows that the boundaries of the model are broad enough for it to be useful in different situations. The sensitivity report, however, does only deviate around the original value with all other variables unchanged. Unwanted effects could still arise when changing two or more variables at the same time. It is impossible, however, to check the infinite amount of possible states this model can be in.

Another arguable assumption made in this study is that of the innovation impatience effect directly influencing the balance through the return on investment on R&D. No previous research has been conducted on the relationship between these factors. It does seem plausible, however, that an unjust withdrawal of innovations directly affects the overall return on investment made on R&D efforts. Also, as mentioned before, the scaling ratio does not matter for the effect to take place; adjusting the ratio either slows the effect down or speeds it up (see appendix, figure 20). The model also lacks the influence of internal forces that drive the ambidexterity level towards exploitation, thus providing a ‘counter weight’. Shareholders short-term orientation for example, which can trigger a success trap (Walrave et al., 2011) could possibly prove to have a larger influence, actually pushing the organization into the opposite direction towards a state of decline. External forces are, however, incorporated into the model to some extend which push towards exploitation.
Since this model only incorporated the *Innovation Impatience Effect*, for further research it would be recommended that the other possible forces (e.g. the *Strategy Incompatibility* or the *First-Mover Effect*) are investigated as well. Especially the mismatch between business strategy and product strategy seems an interesting topic for further research; also in the overall exploration exploitation debate. The disagreement between Liu (2006) and Tripsas & Gavetti (2000), where the first uses the Polaroid case to explain the failure trap, and the latter the same case for explaining the opposite; the success trap, shows the lack of uniformity on the subject and could even raise the question if a success trap and failure trap exist in the way they are described at this point. Also given the fact that the failure trap, simulated in this study, ended up resembling a success trap. This raises questions whether both traps are actually opposites of each other and if they are mutually exclusive rather than being temporally separated. Investigating the underlying interactions and effects on different levels in the company could give new insights on many aspects of management science.

**Conclusion**

With all accumulated knowledge taking into account, it is possible to answer the stated research questions:

1. **What are potential managerial forces that could drive organizations into a failure trap;**

A study of the available literature on the failure trap phenomenon and related topics, led to eight forces that can possibly effect the organization in a way it could get caught in the failure trap. These variables are the *Innovation Extremeness*, the *First-Mover Effect*, the *Risk-Taker Effect*, the *Escalation of Commitment*, the *Aspiration Adjustment Inertia*, the *Innovation Impatience Effect*, the *Absorptive Capacity Effect*, and the *Strategy Incompatibility*.

2. **Which of those forces seems most interesting to be modeled and examined more closely;**

After a review of all possible forces, based on theory and expert input, the *Innovation Impatience Effect* was introduced into the base model to review its effect. Together with the *Strategy Incompatibility*, the *Impatience Effect* was the most interesting force to use in this study. However, at this point too little is known about the effect of the *Strategy Incompatibility* and how it could fit in the process of triggering a failure trap. For this reason the *Impatience Effect* was chosen for this study.

3. **Is this force actually capable of triggering a failure trap, and how does this unfold;**

In the simulated model, the impatience effect was able to trigger a failure trap. The underlying dynamic was set in motion by a deviation of the desired portfolio value and the perceived value. This perceived failure led to management unjustly rejecting innovation before they reached their full potential, leading to a loss in overall R&D RoI. A lower return on investment then led to the need of more innovations to generate the same revenues, moving more and more resources towards exploration at the expense of exploitation efforts. This lowers the RoI on R&D even further, and so on, up to a point where irreversible decline sets in.
4. What are the implications for managers dealing with similar situations?

While the results are arguably hard to generalize, it can be assumed that the effect of innovation impatience has a negative effect on the organization, whether it induces a failure trap or only having a slightly negative effect on the innovation success rate. Therefore, being aware of the symptoms indicating the Run-Up Phase could help management fend off the impending danger of the failure trap before fully getting caught in one. Also, since the Impatience Effect has a negative effect on the success rate of innovations, avoiding this effect helps increasing the firm’s performance.

In conclusion, this research had the aim to explain how the underlying managerial dynamics and processes drive organizations into the failure trap. Given the complexity of this phenomenon, it is unlikely the full dynamic can be simulated. This study, however, did prove the negative effect of innovation impatience, and made several suggestions on other forces that could interrupt the balance between exploration and exploitation, in favor of exploration. Furthermore this article proposed four phases in which the failure trap unfolds itself; the Run-Up Phase; where the organization is not yet caught in the failure trap, but is moving towards the tipping point that trigger the entrapment. The Trigger Phase; the huge increase of exploration efforts, responsible for getting the organization fully caught in the failure trap. The Awareness Phase; the period where management is aware of its failing course and tries everything in its power to adjust it. And the Terminal Phase; where, despite the efforts of management, the organization can at some point no longer exist in its current form, leading to bankruptcy or a takeover.

The simulation also showed that an organization caught in the failure trap, in an attempt to increase performance, could resort to excessive exploitation. This state, caused by overcompensating the previous increase in exploration, resembles a success trap. This paradoxical situation, which could be interpreted as both a failure trap and a success trap, raised new questions on how both traps relate to each other. This knowledge could also be of help in future research on both the success trap and failure trap, and should be kept in mind to prevent falsely labeling a situation as the success trap.

Acknowledgements

The author thanks Bob Walrave for his supervision and diligent reviewing and commenting on this study. Furthermore, thanks to Sjoerd Romme for acting as second supervisor, and to Bert Tuyt and Joni Beysens for making the conducted case study possible.
References


Appendix – Detailed Model Description

Model 1: The Full Model
The model consists of four causal loops; the reinforcing Growth Loop, the balancing Exploration Push Loop, the reinforcing Exploitation Push Loop, and the reinforcing Impatience Loop (See model 1). Below, each loop is emphasized with different colors and reviewed in detail to explain how the loop is realized in the model. The model is developed in VENSIM software and is displayed above.

**Growth Loop (Red)**
The primary loop consists of three stocks; resources, exploration portfolio value (Exploration PV), and exploitation portfolio value (Exploitation PV). This reinforcing loop starts with resources being reinvested into research and development, for the purpose of increasing the Exploration PV (RnD Rate). Then, the value of the Exploration PV stock is depleted via knowledge decay, and is used for commercialization purposes (Commercialization Rate), fuelling the exploitation portfolio value (Exploitation PV). This stock is then depleted by value decay, and by the generation of new resources which on their turn are partly reinvested into more exploration, creating a reinforcing loop.

**Resource stock**
The resource stock is modeled as stated in formula 1.

\[
1) \text{Resources} = \int \text{Inflow} - \text{Outflow} + \text{Initial Value}
\]

With Inflow and Outflow as stated in formula 1A and 1B. All constants (initial values and delay times) are listed in table 2. In equation 1B, the commercialization rate is divided by the RnD RoI, since the profits made on R&D should not be subtracted from the resources.

\[
1A) \text{Inflow} = \frac{\text{Exploitation PV}}{\text{Sales Delay}} \\
1B) \text{Outflow} = \text{RnD Rate} + \left( \frac{\text{Commercialization Rate}}{\text{RnD RoI}} \right)
\]

**Exploration PV Stock**
The Exploration PV stock is modeled as stated in formula 2.

\[
2) \text{Exploration PV} = \int \text{RnD Rate} - \text{Knowledge Decay Rate} + \text{Initial Value}
\]

With RnD Rate and Knowledge Decay Rate stated in formula 2A and 2B. The Knowledge Decay period is a value, fluctuating around an average initial value, influenced by the Market Volatility (formula 2C and...
2D). Market Volatility is a sinus function with periods of high volatility (around 170% of average value) and low volatility (around 30% of average value). This function can be seen in figure 13.

\[
2A) \quad RnD \text{ Rate} = \frac{\text{Resource Reinvestment} \times \text{Resources}}{\text{Sales Delay}} \\
2B) \quad \text{Knowledge Decay Rate} = \frac{\text{Exploration PV}}{\text{Knowledge Decay}} \\
2C) \quad \text{Knowledge Decay} = \text{Average Decay Time} \times \text{Market Volatility} \\
2D) \quad \text{Market Volatility} = 1 - 0.7 \times \sin(0.13 \times \text{time})
\]

**Exploitation PV Stock**

The Exploitation PV stock is modeled as stated in formula 3.

\[
3) \quad \text{Exploitation PV} = \int \text{Commercialization Rate} - \text{Value Decay Rate} + \text{Initial Value}
\]

With Commercialization Rate and Value Decay Rate stated in formula 3A and 3B. The Value Decay period is a value, fluctuating around an average initial value, influenced by the Market Competitiveness (formula 3C and 3D). Market Competitiveness is a sinus function with periods of high competition (around 140% of average value) and low competition (around 60% of average value). This function can be seen in figure 14.

\[
3A) \quad \text{Commercialization Rate} = \frac{\text{Exploration PV} \times \text{RnD RoI}}{\text{Commercialization Delay}} \\
3B) \quad \text{Value Decay Rate} = \frac{\text{Exploitation PV}}{\text{Value Decay}} \\
3C) \quad \text{Value Decay} = \text{Average Decay Time} \times \text{Market Competitiveness} \\
3D) \quad \text{Market Competitiveness} = 1 - 0.4 \times \sin(0.065 \times \text{time})
\]

**Exploration Push Loop (Brown)**

The balancing Exploration Push Loop consists of four stocks: Exploration PV, Perceived Exploration PV, Desired Exploration PV, and Ambidexterity Level. The loop starts out with the Exploration PV having certain value. The perception delay causes the perceived value of the Exploration PV to lack behind. However, it is the Perceived Exploration PV that management is using for its strategic decision making, incorporating another delay. Thus the firms’ targets for the Exploration PV (Desired Exploration PV) also lack behind the Perceived Exploration PV. This effect is shown in figure 15.
Next, the values of the Perceived Exploration PV and the Desired Exploration PV are combined into a ratio; the PDEr Ratio. The more the perceived value diverges from the desired value, the bigger the influence on the ambidexterity level. If the perceived exploration value is very low compared to the desired value, management will adjust the strategy towards more exploration for the sake of creating new venues. When the perceived value is higher than the desired value, management will move the emphasis towards exploitation for the sake of making profits.

**Perceived Exploration PV Stock**

The Perceived Exploration PV stock is modeled as stated in formula 4.

\[
4) \text{Perceived Exploration } PV = \int \text{PErPV Change} + \text{Initial Value}
\]

With the perceived exploration portfolio value change rate, PErPV Change, as stated in formula 4A.

\[
4A) \text{PErPV Change} = \frac{\text{Exploration PV} - \text{Perceived Exploration PV}}{\text{Perception delay in ErPV}}
\]

**Desired Exploration PV Stock**

The Desired Exploration PV stock is modeled as stated in formula 5.

\[
5) \text{Desired Exploration } PV = \int \text{DErPV Change} + \text{Initial Value}
\]

With the desired exploration portfolio value change rate, DErPV Change, as stated in formula 4A.

\[
5A) \text{DErPV Change} = \frac{\text{Perceived Exploration PV} - \text{Desired Exploration PV}}{\text{Goal Adjustment delay in ErPV}}
\]

**Perceived and Desired Exploration Ratio**

Though not a stock, the PDEr Ratio deserves special attention since this ratio is used to simulate managerial decision making. The formula is stated in formula 6. A graph of the PDEr Ratio can be seen in figure 16.
6) \(PDEr \text{ Ratio} = \frac{\text{Desired Exploration PV}}{\text{Perceived Exploration PV}}\)

The output should be interpreted in the following way; at a value higher than 1, the desired value exceeds the perceived value, thus management did not meet their target. At a value lower than 1, the target is met since the perceived value is larger than the desired. Both these states influence the Ambidexterity level set by management.

**Ambidexterity Level Stock**

The Ambidexterity Level stock is modeled to move between 0 and 1, where a level of 0 equals exclusively exploration, and 1 exclusively exploitation. In practice, the optimal state is somewhere in between, as can be seen in figure 12. The Ambidexterity Level value is determined by \(PDEr\) Ratio, discussed above, and the Perceived and Desired Exploitation Ratio (\(PDEi\) Ratio); a similar ratio used in the Exploitation Push Loop discussed below. As mentioned, a value above 1 indicates that targets are not met, thus if the \(PDEr\) Ratio is above 1, more resources are needed in the RnD Rate. However, since the model assumes that resources are finite, moving resources towards exploration means moving them away from exploitation. The focus is therefore determined by the highest ratio; if \(PDEr\) Ratio is 1.1 and the \(PDEi\) Ratio is 1.3 the model assumes that, while both exploration and exploitation require more resources, exploration is more urgent since there is need for new exploitable innovations. The formula for ambidexterity level is stated in formula 7.

7) \(\text{Ambidexterity Level} = \int \text{Change}\)

The formula for Change is stated in formula 7A¹. The constant 0.01 is used to decrease the impact of the difference between the ratios. Without this constant, the level would change in a way too fast manner which leads to the model being unrealistic. The stock does not have a delay of its own since these are incorporated into the two ratio’s.

\[
7A¹ \) \text{Change} = 0.01 \ast (PDEr \text{ Ratio} - PDEi \text{ Ratio})
\]

There are extreme situations where, using formula \(7A¹\), the model is capable of increasing the Ambidexterity Level stock above 1 or below 0. This is undesired since it is impossible in a real situation. To prevent this from happening, a double, nested, conditional expression is used in the formula. This leads to formula \(7A²\) being used in the model to calculate Change.

\[
7A² \) \text{Change} = IF(0.01 \ast (PDEr \text{ Ratio} - PDEi \text{ Ratio}) + \text{Ambidexterity Level} > 1), THEN(0), ELSE(IF(0.01 \ast (PDEr \text{ Ratio} - PDEi \text{ Ratio}) + \text{Ambidexterity Level} < 0), THEN(0), ELSE(0.01 \ast PDEr \text{ Ratio} - PDEi \text{ Ratio})))
\]
**Resource Reinvestment**

This variable determines the amount of resources that are reinvested into R&D, and is influenced by the Ambidexterity Level. The lower the Ambidexterity Level, the more focus on exploration, thus the higher this reinvestment will be. This amount is not linear to the ambidexterity level; the higher the RnD Rate is, the harder it will be to increase it even further. Therefore, a lookup function is used that follows logarithmic growth as can be seen in figure 17, where \( x = \) ambidexterity level, and \( y = \% \) reinvested in RnD. The variable is stated in function 8. Since the model runs on a monthly basis, the percentages have to be converted to monthly instead of annually.

8) **Resource Reinvestment**

\[
8) \text{Resource Reinvestment} = \left(12\sqrt{1 + \text{Reinvestment Lookup}}(1 - \text{Ambidexterity Level}) - 1\right)
\]

**Exploitation Push Loop (Purple)**

The balancing Exploitation Push Loop consists of four stocks; Exploitation PV, Perceived Exploitation PV, Desired Exploitation PV, and Ambidexterity Level. The loop works in a similar way as the Exploration Push Loop, discussed above; the differences between perceived and desired value generate a ratio named the PDEi Ratio, which influences the Ambidexterity Level.

**Perceived Exploitation PV Stock**

The Perceived Exploitation PV stock is modeled as stated in formula 9.

9) **Perceived Exploitation PV** = \( \int \text{PEiPV Change} + \text{Initial Value} \)

With the perceived exploitation portfolio value change rate, PEiPV Change, as stated in formula 9A.

9A) **PEiPV Change** = \( \frac{\text{Exploitation PV} - \text{Perceived Exploitation PV}}{\text{Perception delay in EiPV}} \)

**Desired Exploitation PV Stock**

The Desired Exploitation PV stock is modeled as stated in formula 10.

10) **Desired Exploitation PV** = \( \int \text{DEiPV Change} + \text{Initial Value} \)

With the desired exploitation portfolio value change rate, DEiPV Change, as stated in formula 10A.

10A) **DEiPV Change** = \( \frac{\text{Perceived Exploitation PV} - \text{Desired Exploitation PV}}{\text{Goal Adjustment delay in EiPV}} \)
**Perceived and Desired Exploitation Ratio**

Also not a stock, but the PDEi Ratio deserves special attention since this ratio is used to simulate managerial decision making. The formula is stated in formula 11. A graph of the PDEi Ratio can be seen in figure 18.

\[ 11) \quad PDEi \, Ratio = \frac{Desired \, Exploitation \, PV}{Perceived \, Exploitation \, PV} \]

The output should be interpreted the same way as the PDEr Ratio.

**R&D Return on Investment**

This variable determines the return on investment that is made on R&D, and is influenced by the Ambidexterity Level. The higher the Ambidexterity Level, the more focus on exploitation, thus the higher this RoI will be. Similar to the Resource Reinvestment, this amount is not linear to the ambidexterity level; the higher the RoI is, the harder it will be to increase it even further. Therefore, a lookup function is used that follows logarithmic growth as can be seen in figure 19, where \( x = \) ambidexterity level, and \( y = \) RoI %. The variable is stated in function 12. Since the model runs on a monthly basis, the percentages have to be converted to monthly instead of annually. The Impatience Level variable is discussed below with the Impatience Loop.

\[ 12) \quad RnD \, RoI = \sqrt[12]{1 + \text{RoI Lookup}(Ambidexterity \, Level)} \times \text{Impatience \, Level} \]
**Impatience Loop (Green)**

This reinforcing loop simulates the effect of innovation impatience as discussed in the article. It consists of one stock that is influenced by the PDEi Ratio. Since it is assumed that in periods of decline in exploitation portfolio value, and with that; resources, management possibly reacts with the unjust withdrawal of innovation. The Impatience Level is a ratio that directly influences the RnD RoI. It is however able to go below 0, since this represents a state where innovation actually costs resources instead of generating them. The Impatience Level stock is stated in formula 13.

\[
13) \text{Impatience Level} = \int \text{Impatience Rate} + 1
\]

The Impatience Rate is stated in formula 13A. This rate consists of the Impatience Delay, which is changed to test the impact of stressed reactions of the management, and the Adjusted PDEi Ratio (formula 13B). The PDEi has to be adjusted in two ways; first it has to be inverted since a higher PDEi equals lower perceived value compared to the desired value, but it should also lower Impatience Level. The lower the level of impatience, the lower the RoI. Second, its impact has to be decreased to lessen the effect of the ratio on the Impatience Level and keep the time in which change is realized realistic. This Impact Factor is set to 0.24 which is found by trial and error to provide realistic output. This value of 0.24 can be changed to increase or decrease the effect of Innovation Impatience. However, this will lead to similar results. In figure 20, graphs can be seen with the effect being both increased and decreased by 50%. A visualization of the PDEi Ratio compared to the Adjusted PDEi Ratio can be seen in figure 21.

\[
13A) \text{Impatience Rate} = \frac{\text{Adjusted PDEi Ratio}}{\text{Impatience Delay}}
\]

\[
13B) \text{Adjusted PDEi Ratio} = (1 – \text{PDEi Ratio}) \times \text{Impact Factor}
\]
Initial Values and Constants

The base model, on which the determinants can be tested, is theoretical. However, to ensure is remains realistic, it is loosely based on the data gathered with the case study conducted at one of the world’s largest lighting manufacturers. The theoretical company has characteristics as stated in table 2.

<table>
<thead>
<tr>
<th>Table 2 – Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Market information</strong></td>
<td></td>
</tr>
<tr>
<td>Market</td>
<td>Medium / highly dynamic (similar to lighting)</td>
</tr>
<tr>
<td>Size</td>
<td>Large multinational</td>
</tr>
<tr>
<td>Competitive Position</td>
<td>Top-3 player</td>
</tr>
<tr>
<td>Value Decay Time</td>
<td>36 Months Full Decay</td>
</tr>
<tr>
<td>Knowledge Decay Time</td>
<td>24 Months Full Decay</td>
</tr>
<tr>
<td><strong>Initial Values</strong></td>
<td></td>
</tr>
<tr>
<td>Resources</td>
<td>€105,000,000</td>
</tr>
<tr>
<td>Exploration / Exploitation ratio (ambidexterity level)</td>
<td>0.7 / 0.3</td>
</tr>
<tr>
<td>Exploration Portfolio Value</td>
<td>€75,000,000</td>
</tr>
<tr>
<td>Exploitation Portfolio Value</td>
<td>€75,000,000</td>
</tr>
<tr>
<td>Impatience Level</td>
<td>1 (= no effect on RnD RoI)</td>
</tr>
<tr>
<td><strong>Delays</strong></td>
<td></td>
</tr>
<tr>
<td>Development Time (RnD Delay)</td>
<td>11 Months</td>
</tr>
<tr>
<td>Lab-to-Market Time (Commercialization Delay)</td>
<td>9 Months</td>
</tr>
<tr>
<td>Sales Delay</td>
<td>9 Months</td>
</tr>
<tr>
<td>Perception Delay (both EiPV and ErPV)</td>
<td>6 Months</td>
</tr>
<tr>
<td>Goal Adjustment Delay (both EiPV and ErPV)</td>
<td>12 Months</td>
</tr>
<tr>
<td>Impatience Delay</td>
<td>Subject to change</td>
</tr>
<tr>
<td><strong>Important Parameters</strong></td>
<td></td>
</tr>
<tr>
<td>Model Runtime</td>
<td>300 Months (25 years)</td>
</tr>
<tr>
<td>Time step</td>
<td>0.25 (1 week)</td>
</tr>
</tbody>
</table>
Sensitivity Report

To increase the generalizability of the model a sensitivity analysis is conducted. It shows to what extent a constant, or an initial value can differ and still let the model remain viable. All constants and initial values are increased and decreased until the model crashes or starts to behave unrealistic. This is done up to either an increase of 500% or a decrease of 90%. Beyond these points, if the model still behaves normally, it is assumed that further altering the value will also have no impact.

Very important to note is that the altering of one value is done with each other value left as it is. This means that altering several values at the same time can have severe consequences for the stability of the model. Since there are infinite ways to alter combinations of variables in the model, this is not included in this sensitivity report.

The sensitivity testing is conducted without the influence of the Impatience Loop, since testing its impact is the main subject of the article and testing without it ensures the base model behaving realistic. Because of this, the altering of values in a way that sets the company in decline from the start, or that moves the Ambidexterity Level towards either 0 or 1 without the Impatience effect, are also seen as unrealistic. This is because it would then be impossible to test if the Innovation Impatience Effect can trap the company in irreversible decline.

<table>
<thead>
<tr>
<th>Table 3 – Model Validity</th>
<th>Lower Bound</th>
<th>Value (t=0)</th>
<th>Upper Bound</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>RnD Delay</td>
<td>-90%</td>
<td>11 months</td>
<td>+55%</td>
<td></td>
</tr>
<tr>
<td>Exploration PV</td>
<td>-42%</td>
<td>€75 million</td>
<td>+500%</td>
<td></td>
</tr>
<tr>
<td>Perception Delay in ErPV</td>
<td>-55%</td>
<td>6 months</td>
<td>+500%</td>
<td></td>
</tr>
<tr>
<td>Goal Adjustment Delay in ErPV</td>
<td>-90%</td>
<td>12 months</td>
<td>+9%</td>
<td>Model stability is very dependent on the difference between these values</td>
</tr>
<tr>
<td>Sales Delay</td>
<td>-70%</td>
<td>9 months</td>
<td>+51%</td>
<td></td>
</tr>
<tr>
<td>Resources</td>
<td>-90%</td>
<td>€105 million</td>
<td>+500%</td>
<td></td>
</tr>
<tr>
<td>Commercialization Delay</td>
<td>-80%</td>
<td>9 months</td>
<td>+500%</td>
<td></td>
</tr>
<tr>
<td>Exploitation PV</td>
<td>-90%</td>
<td>€75 million</td>
<td>+500%</td>
<td></td>
</tr>
<tr>
<td>Perception Delay in EiPV</td>
<td>-90%</td>
<td>6 months</td>
<td>+500%</td>
<td></td>
</tr>
<tr>
<td>Goal Adjustment Delay in EiPV</td>
<td>-59%</td>
<td>12 months</td>
<td>+500%</td>
<td></td>
</tr>
<tr>
<td>Market Volatility</td>
<td>-90%</td>
<td>1 - 0.7 * sin(0.13x)</td>
<td>+40%</td>
<td>At a higher increase than the upper bound, the sine return negative values</td>
</tr>
<tr>
<td>Market Competitiveness</td>
<td>-33%</td>
<td>1 - 0.4 * sin(0.065x)</td>
<td>+210%</td>
<td></td>
</tr>
</tbody>
</table>