

# IMITATION STRATEGIES IN A RANDOM UTILITY FRAMEWORK: WHO DO FIRMS IMITATE?

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## Abstract

*The main purpose of this study is to provide an internally valid empirical foundation for the use of imitation strategies in the development of technology by firms. To this end, we integrate previous findings into a single theoretical framework that is based on random utility theory. We focus on the discrete choice for an imitation strategy and include environmental and firm attributes to explain this choice. We present the results of discrete choice experiments that were administered to managers of Dutch high-tech firms in the form of an online survey. Two methods of analysis were used; multinomial logit models and generalized estimating equations models. On the one hand, we confirm the predictions in contemporary literature for the rate of technological development, past behavior, innovation strategy, risk propensity, technological knowledge base and network structures. On the other hand, we find a result for technological uncertainty that contradicts predictions in strategic management literature, neo-institutional literature and literature on organizational learning. Furthermore, we show that high status firms function as opinion leaders for the imitation of technology and that firms are more inclined to base their decision on a trait of the imitated firm than on the frequency of use of a technology.*

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# 1. INTRODUCTION

*“In the past two decades...theorists have increasingly emphasized processes through which individual organizations may be influenced by other organizations. One such process is inter-organizational imitation, which occurs when one or more organizations’ use of a practice increases the likelihood of that practice being used by other organizations.” (Haunschild and Miner, 1997, pp.472).*

Inter-organizational imitation plays an important role in contemporary business (Ordanini *et al.*, 2008); organizations imitate each other’s technologies, competitive strategies and business methods (Barreto and Baden-Fuller, 2006). Inter-organizational imitation plays a large role in society as a whole as well; it influences the adoption of technology (Young, 2005), causes firms in similar environments to resemble one another (DiMaggio and Powell, 1983) and affects the spread of policy measures between states or countries (Busch and Jörgens, 2005).

This study focuses on the imitation of technology by firms. The imitation of technology is widely recognized as a fundamental aspect of the competitive process (Lieberman and Asaba, 2006) and has been studied extensively by authors in strategic management literature (e.g. Lieberman and Montgomery, 1988; Zhou, 2006; Suarez and Lanzolla, 2007). These authors focus on the use of *strategies* in technological development. The *motive* of firms to use a particular strategy is that it helps them gain a competitive advantage over a rival firm. They use entry timing to differentiate between strategies; pioneer, fast follower and late follower strategies. Pioneers rely on *individual* development of technology, while others rely on *imitation*. Although these authors explain why firms choose to develop technology individually rather than imitate others, they do not specify what firms are imitated exactly and why these particular firms are imitated.

This matter is partially explained in other literatures on inter-organizational imitation. Haunschild and Miner (1997) identify three types of imitation; frequency-based, trait-based and outcome-based imitation. They argue that imitation is based on the frequency of use of a technology, on firms with particular traits or on a technology with a successful outcome, respectively. Other authors investigate imitation based on peers (Tingling and Parent, 2002), successful firms (Denrell, 2003), the average of other firms (Massini *et al.*, 2005), successful innovators (Massini *et al.*, 2005) and groups identified by legitimacy providers, such as media or regulators (Barreto and Baden-Fuller, 2006). These authors generally focus on a single motive for imitation and rarely incorporate the results of other literatures, most notably strategic management literature. This implies that important predictors for imitation in one study are often completely disregarded in another study, which analyzes imitation from a different perspective. The disregard of these rival explanations leads to questionable results due to a *low internal validity* (Bryman, 2008). In other words, the provided explanations for imitation are only valid in the particular situation where the firm uses the motive for imitation that is specified by that literature.

The main purpose of this study is to provide an internally valid empirical foundation for the use of firm strategies that specify *who* these firms imitate, which we term imitation strategies. To this end, we combine insights from different perspectives on imitation into a single theoretical model. Rather than focusing on the outcome of imitation (i.e. the observation that firms use the same technology), we model imitation as a *discrete choice*. The latter method leads to a higher internal validity of the results (Ryan *et al.*, 2004) as outcome based methods do not clarify if a firm actually imitates or just responds to a particular external stimulus in the same way as another firm. It is generally accepted that environmental attributes and firm attributes affect the choice for strategies in general (Covin *et al.*, 2000) as well as the choice for a specific imitation strategy (Ordanini *et al.*, 2008). For the sake of parsimony, we limit our study to these two types of attributes. This leads to the following research question:

*What environmental and firm attributes affect the choice for an imitation strategy in the development of technology by firms?*

We exclusively study imitation between firms in the same competitive environment to enable a unification of strategic management literature with other literatures. Although we recognize that other types of actors (e.g. universities or knowledge institutes) can also be imitated, this type of imitation would not involve the strategic motives that are central to strategic management literature (i.e. a competitive advantage over a rival). A further delineation is that we do not study the actual transfer of technological knowledge, but rather the imitation of another firm's decision to use a particular technology. In this case, firms become knowledgeable about other firms' developments through a process of observation (Huber, 1991) or by close involvement between members of a formal collaborative structure (Baum and Ingram, 1998).

The study leads to several practical implications for policy that aims to increase the use of particular technologies, such as sustainable energy technologies or efficiency improvements. We argue that this type of policy should be directed at opinion leaders; we show what firms serve as opinion leaders for the use of technology and how this differs between environments. The study also leads to several implications for firms that aim to avoid or stimulate imitation of their technology. We show which environments are conducive to imitation and from which type of firms imitation can be expected.

We first present a review of contemporary literature on the imitation of technology by firms. This review establishes the current theoretical insights on the subject and focuses on the motives for imitation and the imitation strategies, environmental and firm attributes that are deduced from this motive. These insights are combined into a theoretical framework that is based on random utility theory (RUT) (McFadden, 1973; Manski, 1977). Random utility theory can unify current theoretical insights by expressing each imitation strategy as having a particular utility, or value. This allows a multitude of motives to be combined into a single concept; utility. Subsequently, we present the results of discrete choice experiments (DCEs) (Hensher *et al.*, 2005) that establish what imitation strategies have the highest utility and how this utility is affected by environmental and firm attributes. Finally, we provide a conclusion, a discussion and implications of the study.

## 2. THEORY

### 2.1. THEORETICAL BACKGROUND

The review of contemporary literature focuses on the motives for imitation in each literature and the imitation strategies, environmental and firm attributes that are deduced from this motive. We study literatures on the firm and environmental level of analysis that offer specific indications for the imitation of *technology*. Completeness has been attempted by examining several reviews on inter-organizational imitation (Lieberman and Asaba, 2006; Ordanini *et al.*, 2008), first mover advantages (Suarez and Lanzolla, 2007) and organizational change (Lewin *et al.*, 2004). A summary of the literature review is displayed in table 1.

#### ***Strategic management***

In strategic management literature imitation is studied at the firm level (Lieberman and Montgomery 1988; Covin *et al.*, 2000; Zhou, 2006; Suarez and Lanzolla, 2007). The central object of study is the effect of strategies on the competitive advantage of firms. The concept of entry timing is used to differentiate between strategies; pioneer, fast follower and late follower strategies. A pioneer develops technology individually, while others imitate the pioneer.

Pioneers are often able to secure a competitive advantage by patenting and by promoting learning effects on the technology (Lieberman and Montgomery, 1988). However, some environments are less conducive to patenting and learning effects and tend to favor a follower strategy (Zhou, 2006; Suarez and Lanzolla, 2007). Environmental change is an important determinant of the ease at which pioneers can secure a competitive advantage (Suarez and Lanzolla, 2007). Environmental change can be measured by two dimensions of change; the uncertainty of change and the frequency of change (Damanpour and Gopalakrishnan, 1998). Besides environmental change, the role of novelty related (i.e. new to firm or new to market) innovation strategies is stressed in this literature (Li and Atuahene-Gima, 2001).

#### ***Organizational learning***

In literature on organizational learning imitation is also studied at the firm level, but the focus is on strategies for learning rather than entry timing strategies (Dutton and Freedman, 1985; Levitt and March, 1988; Huber, 1991; March, 1991; Baum and Ingram, 1998; He and Wong, 2004). Firms that imitate others can leave the exploration of technological possibilities to other firms. The exploration of technology requires substantial investments in R&D capabilities, which can be avoided by imitating others (Dutton and Freedman, 1985; March, 1991). This is most valuable in environments where the outcome of technological development is uncertain due to the presence of multiple development paths (Levitt and March, 1988).

The imitation of another firm requires the sharing of detailed information. Sharing detailed information is simpler when firms have extensive social contact, such as firms in the same network (Williamson and Cable, 2003). Firms with an extensive network structure are more likely to have detailed information about other firms, which facilitates imitation (Granovetter, 1985; Gulati *et al.*, 2000). Besides network structures, the roles of knowledge base (Cohen and Levinthal, 1990) and past behavior (March, 1988) are stressed in this literature.

### ***Neo-institutional literature***

In this literature imitation is studied at the environmental level; the phenomenon of mimetic isomorphism (DiMaggio and Powell, 1983; Haunschild and Miner, 1997; Henisz and Delios, 2001; Barreto and Baden-Fuller, 2006; Hung, 2008; Gao 2010), or the observation that firms confronted by a particular environment are homogeneous (isomorphism), because these firms imitate each other (*mimetic* isomorphism). Imitation is an attempt of firms to reduce uncertainty, especially when the uncertainty in the environment is high or when firms have little experience with the reduction of uncertainty (DiMaggio and Powell, 1983). In addition, the imitation of high status firms or the majority of firms can contribute to the legitimacy of the imitator firm (DiMaggio and Powell, 1983).

### ***Herd behavior***

In literature on herd behavior imitation is also studied at the environmental level. The role of managerial action in imitation is stressed in this literature, while this is largely ignored in neo-institutional literature (Banerjee, 1992; Abrahamson and Rosenkopf, 1993; Ellison and Fudenberg, 1995; Bikhchandani, *et al.*, 1998). The imitation of other firms reduces the risk of technological development, especially when a technology is used by the majority of firms (Banerjee, 1992). The reduction of risk is especially valuable for firms that have a low propensity for risk. Another motive for imitation is that it helps to avoid a negative managerial reputation; managers may ignore internal information in order to be evaluated well by peers (Scharfstein and Stein, 1990). In this case, firms will imitate those firms with a superior reputation; high status firms.

Literature	Level of analysis	Motives for imitation	Environmental attributes	Firm attributes	Imitation strategies	Important contributions
Strategic management	Firm	◦Competitive advantage	◦Uncertainty of change ◦Rate of change	◦Innovation strategy	◦Follow the pioneer	Lieberman and Montgomery, 1988; Damanpour and Gopalakrishnan, 1998; Covin <i>et al.</i> , 2000; Zhou, 2006; Suarez and Lanzolla, 2007
Organizational learning	Firm	◦Save exploration costs	◦Uncertainty	◦Network structures ◦Past imitation strategy ◦Knowledge base	◦Network	Dutton and Freedman, 1985; Levitt and March, 1988; March, 1991; Huber, 1991; Baum and Ingram, 1998
Neo institutional literature	Environment	◦Reduce uncertainty ◦Gain legitimacy	◦Uncertainty		◦High status ◦Majority	DiMaggio and Powell, 1983; Haunschild and Miner, 1997; Henisz and Delios, 2001; Barreto and Baden-Fuller, 2006
Herd behavior	Environment	◦Reduce risk ◦Avoid a negative managerial reputation		◦Risk propensity	◦High status ◦Majority	Scharfstein and Stein, 1990; Banerjee, 1992; Abrahamson and Rosenkopf, 1993;

*Table 1:* Summary of literature review.

## 2.2. THEORETICAL FRAMEWORK

As mentioned previously, the main purpose of this study is to provide an internally valid empirical foundation for the use of imitation strategies by firms. The approach we take to accomplish this purpose is to consider multiple motives for imitation that originate from different literatures on imitation (discussed in the previous section) and integrate these perspectives into a single theoretical framework that is based on random utility theory (RUT). RUT relies on the assumption of utility maximization. This assumption implies that a firm chooses the imitation strategy with the highest utility. The variability of this choice has two components; variability *between* firms' choices and variability *within* firms' choices (Thurstone, 1927). To reflect the variability within firms' choices utility is modeled as a random variable (McFadden, 1973; Manski, 1977; Ben-Akiva and Bierlaire, 1999):

$$U_i = V_i + \varepsilon_i$$

The utility ( $U_i$ ) of imitation strategy  $i$  is the main object of analysis. This utility consists of a deterministic component ( $V_i$ ) and an error component ( $\varepsilon_i$ ). The deterministic component contains all the attributes that were *observed* in the study, which are four environmental and five firm attributes. Although other attributes can influence the utility of an imitation strategy, we have delineated the study to firm and environmental attributes and used a literature review to select the most important ones, all for the sake of parsimony. These other attributes are *unobserved* in the study and are contained in the error component, as well as measurement errors. The conceptual model shows which firm and environmental attributes were observed in the study and what the expected relations between imitation strategy, environmental attributes and firm attributes are (figure 1). The specific strategies, environmental and firm attributes are discussed in the next sections, along with the expected relations between these concepts.

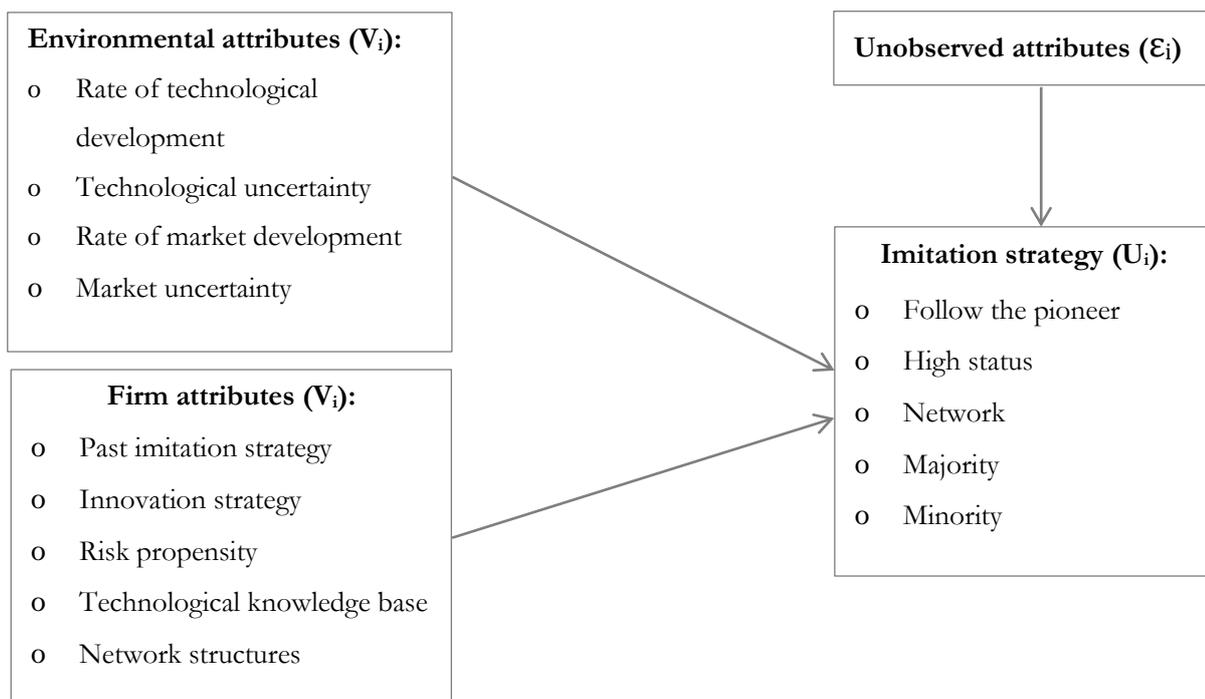


Figure 1; Conceptual model

### **2.2.1. IMITATION STRATEGIES**

Contemporary literature on the imitation of technology has been consulted to identify several imitation strategies. The imitation strategies are based on a trait of the firm that uses the technology or on the frequency of use of the technology (Haunschild and Miner, 1997). Outcome based imitation is excluded, because this type of imitation is based on the technology itself rather than on the firms that use the technology. To determine the utility of the imitation strategies we compare them to a pioneer strategy, which relies on individual development rather than imitation.

#### ***Pioneer strategy***

A firm that uses a pioneer strategy explores technological possibilities internally and bases its choice for a technology on the results of this exploration process. This strategy serves as the reference case against which all other strategies are compared. The main advantage of this strategy is that it increases the odds of a competitive advantage in some environments (Suarez and Lanzolla, 2007). In addition, a pioneer strategy does not suffer from some of the problems of imitation; the imitation of technology can result in compatibility problems between the new and old technologies (Probst *et al.*, 1998) and the actions of other firms can be misinterpreted, which leads to suboptimal imitation (Rivkin, 2000).

#### ***Follow the pioneer strategy***

A firm that uses a follow-the-pioneer strategy imitates the firm that *currently* competes at the forefront of technological development. An advantage of this strategy is that it enables the firm to gain a competitive advantage over the pioneer in some environments (Suarez and Lanzolla, 2007). In addition, it allows the firm to reduce uncertainty (DiMaggio and Powell, 1983), reduce risk (Banerjee, 1992) and save costs on the exploration of technology (Levitt and March, 1988).

#### ***High status strategy***

A firm that uses a high status strategy imitates firms that have a high status, which refers to the *past* success of a firm in introducing innovations (Massini *et al.*, 2005). Besides the reduction of uncertainty (DiMaggio and Powell, 1983), the reduction of risk (Banerjee, 1992) and the costs saved on the exploration of technology (Levitt and March, 1988), a high status strategy offers a high amount of legitimacy (DiMaggio and Powell, 1983).

#### ***Network Strategy***

A firm that uses a network strategy imitates its network partners. Network partners have a history of sharing detailed information with each other, which facilitates imitation and decreases the costs for technological development (Williamson and Cable, 2003). This high potential for cost savings is an advantage of a network strategy. It also offers some of the other advantages of other imitation strategies; reduced risk (Banerjee, 1992) and reduced uncertainty (DiMaggio and Powell, 1983).

### ***Majority strategy***

A firm that uses a majority strategy imitates the majority of firms in a particular market. Besides the reduction of uncertainty (DiMaggio and Powell, 1983), the reduction of risk (Banerjee, 1992) and the costs saved on the exploration of technology (Levitt and March, 1988), a majority strategy offers a high amount of legitimacy (DiMaggio and Powell, 1983).

### ***Minority strategy***

A firm that uses a minority strategy imitates the minority of firms in a particular market. This strategy is the exact opposite of a majority strategy. Firms use this strategy when they want to use a technology that is less widespread than the majority technology. This allows the firm to differentiate from most competitors. This strategy also offers risk reduction (Banerjee, 1992), uncertainty reduction (DiMaggio and Powell, 1983) and cost savings (Levitt and March, 1988).

## **2.2.2. ENVIRONMENTAL ATTRIBUTES**

The environment that is studied here is the competitive environment. We define this environment as a system that is external to the firm (Ackoff, 1981) and that consists of a number of competing firms that offer a particular product to a particular customer group. This definition entails that we assume that environmental *change* is also external to the firm and that we do not take the influence of firm behavior on the environment into account. The uncertainty and rate of change in the environment affect the strategies for technological development that a firm uses (Damanpour and Gopalakrishnan, 1998). The uncertainty and rate of change can further be classified according to the source of change; development of technology or development of the market (Suarez and Lanzolla, 2007).

### ***Rate of technological development***

The rate of technological development is defined as the frequency of changes in the technology used in a product (Zhou, 2006). When the rate of technological development is high, new product models are replaced in rapid succession; every year or every few months. When the rate of technological development is low, the replacement rate of new product models is lower; three to five years.

Pioneers are often able to secure a competitive advantage by patenting and by promoting learning effects on the technology (Lieberman and Montgomery, 1988). This advantage is difficult to sustain when technology improves rapidly (Suarez and Lanzolla, 2007). When a new version of the technology does appear, pioneers often demonstrate ‘incumbent inertia’ (Lieberman and Montgomery, 1988). Thus, pioneers can more easily maintain a competitive advantage when the rate of technological development is low rather than high. However, a low rate of technological development limits the managerial attention for technological development and decreases the impetus to invest in R&D capabilities. The lack of urgency for technological development causes firms to be more inclined to use imitation strategies (Damanpour and Gopalakrishnan, 1998), even though a pioneer strategy can lead to a substantial competitive advantage.

***H1:*** If the rate of technological development is *high* rather than low, the utility of a follow-the-pioneer, high status, network, majority or minority strategy *decreases* relative to a pioneer strategy.

### ***Uncertainty of technological development***

The uncertainty of technological development is defined as the difficulty of predicting the future development of a technology. When this development is uncertain, multiple separate paths for developing a technology are present (Levitt and March, 1988). An example of uncertain technological development was the competition between HDD and Blu-ray as alternatives for storage and playback of high definition video content (Van Rijnsoever and Oppewal, 2012). Contrastingly, when there is a single path for technological development, the outcome of technological development is much more predictable (Levitt and March, 1988).

The imitation of other firms offers a way to resolve the uncertainty of technological development, which increases the attractiveness of imitation strategies in these environments (DiMaggio and Powell, 1983; Hung, 2008). At the same time, the difficulty of predicting the outcome of technological development increases the risk of early investments in a technology (Levitt and March, 1988), which decreases the attractiveness of a pioneer strategy.

**H2:** If the development of technology is *uncertain* rather than certain, the utility of a follow-the-pioneer, high status, network, majority or minority strategy *increases* relative to a pioneer strategy.

### ***Rate of market development***

The rate of market development is defined as the frequency of changes in the market for a product (Zhou, 2006). When the rate of market development is high, customer preferences change frequently and new market niches develop often. When the rate of market development is low, customer preferences are stable over a long period of time.

In the latter environment, pioneers can secure a competitive advantage through economies of scale and scope (Kerin *et al.*, 1992). This advantage is difficult to sustain when customer preferences change frequently (Golder and Tellis, 1993). Imitators can wait for customer preferences to coalesce and then identify a market position that is superior to the one occupied by the pioneer (Zhou, 2006). Thus, pioneers can more easily maintain a competitive advantage when the rate of market development is low rather than high. However, a low rate of market development leads to a lack of urgency for technological development, as is the case with a low rate of technological development (Damanpour and Gopalakrishnan, 1998). This will generally cause firms to be more inclined to use imitation strategies, even though a pioneer strategy can lead to a substantial competitive advantage.

**H3:** If the rate of market development is *high* rather than low, the utility of a follow-the-pioneer, high status, network, majority or minority strategy *decreases* relative to a pioneer strategy.

### ***Uncertainty of market development***

The uncertainty of market development is defined as the difficulty of predicting the development of firm market shares. This development is uncertain when market competition and firm failure rates are high. Contrastingly, this development is certain when market competition and firm failure rates are low (Covin and Slevin, 1989). Intensive market competition creates uncertainty (DiMaggio and Powell, 1983), which complicates the choice process. In that case, it is simpler and more efficient to imitate others (Gao, 2010).

**H4:** If the development of the market is *uncertain* rather than certain, the utility of a follow-the-pioneer, high status, network, majority or minority strategy *increases* relative to a pioneer strategy.

### ***Interaction of uncertainty and rate of development***

In addition to the separate effects of uncertainty and rate of development, the interaction between these attributes is underlined in literature on imitation (Damanpour and Gopalakrishnan, 1998). If both uncertainty and rate of development are high, two opposing mechanisms are at play. On the one hand, firms will be inclined to imitate to reduce uncertainty (DiMaggio and Powell, 1983). On the other hand, firms have a sense of urgency for technological development that generally stimulates them to use a pioneer strategy (Damanpour and Gopalakrishnan, 1998). We predict that firms will be more inclined to imitate in these environments as this allows them to reduce uncertainty. However, they will be less inclined to wait until a majority has formed for a particular new technology due to the sense of urgency for technological development.

**H5:** When the rate of technological development is *high* and the development is *uncertain*, the utility of a follow-the-pioneer, high status, network or minority strategy *increases* and the utility of a majority strategy *decreases* relative to a pioneer strategy.

**H6:** When the rate of market development is *high* and the development is *uncertain*, the utility of a follow-the-pioneer, high status, network or minority strategy *increases* and the utility of a majority strategy *decreases* relative to a pioneer strategy.

### **2.2.3. FIRM ATTRIBUTES**

Besides attributes of the environment, we investigate two types of firm attributes; firm strategy and firm capabilities. The strategy of a firm reflects what the firm wants to achieve with technological development. Each imitation strategy offers particular advantages, which implies that some imitation strategies are better equipped for a particular type of technological development (Damanpour and Gopalakrishnan, 1998). We examine three dimensions of strategy; past imitation strategy, innovation strategy and risk propensity. Second, the particular capabilities of a firm determine whether a firm can actually carry out a particular imitation strategy (Lieberman and Asaba, 2006). We examine two dimensions of firm capabilities; technological knowledge base and network structures. Finally, we include two firm attributes as control variables; age and size.

### **Past imitation strategy**

The past imitation strategy of a firm reflects what combination of strategies a firm has used in the past. Repeated use of a particular imitation strategy creates firm routines, rules of thumb (March, 1988; Ellison and Fudenberg, 1993) and particular goals for technological development (Lewin *et al.*, 2004). Thus, recent experience with an imitation strategy provides a guide for future behavior (Van Rijnsoever *et al.*, 2012). It can even create inertia (Hannan and Freeman, 1984), which will make it more difficult for the firm to use other imitation strategies. Thus, when a firm has used an imitation strategy extensively in the past, it will be more inclined to use this same strategy in the future.

**H7:** The *higher* the past use of a particular strategy, the *higher* the utility of that particular strategy relative to a pioneer strategy.

### **Innovation strategy**

The innovation strategy of a firm is defined as a firm's commitment to create a particular type of innovation based on novelty (Li and Atuahene-Gima, 2001). Three innovation strategies are considered in this study; a firm develops innovations that are new to the market, new to the firm or only incremental improvements to existing products. A firm that is committed to develop new-to-the-market innovations will benefit from using a pioneer strategy as this strategy allows the firm to develop something completely new. If a firm is committed to develop new-to-the-firm innovations, imitation strategies are a viable alternative to a pioneer strategy, because the innovation does not have to be entirely new. However, imitation is selective in this case as innovative firms are inclined to imitate other innovative firms, while non-innovative firms are inclined to imitate the majority of other firms (Massini *et al.*, 2005). We do not predict any influence of a new to the firm strategy on other imitation strategies. The incremental improvement strategy serves as a reference case for comparison.

**H8a:** If the firm uses a *new to the market* innovation strategy rather than an incremental improvement strategy, the utility of a follow-the-pioneer, high status, network, majority or minority strategy *decreases* relative to a pioneer strategy.

**H8b:** When the firm uses a *new to the firm* innovation strategy rather than an incremental improvement strategy, the utility of a follow the pioneer or high status strategy *increases* and the utility of a majority strategy *decreases* relative to a pioneer strategy.

### **Risk propensity**

The risk propensity of a firm reflects the amount of risk involved in the strategies of the firm (Venkatraman, 1989). A strategy for technological development involves less risk when the consequences of failure are widely shared between a large number of firms (Banerjee, 1992) or when the consequences can be resolved within a network of firms. Other strategies generally involve more risk precisely by sharing the technology with a smaller number of firms, which can result in large losses of market share when the technology fails and another, which is supported by the majority, succeeds. Firms that have a high propensity for risk are more willing to use strategies with a high risk profile.

**H9:** The *higher* the risk propensity of a firm, the *higher* the utility of a follow-the-pioneer, high status or minority strategy and the *lower* the utility of a network or majority strategy relative to a pioneer strategy.

### ***Technological knowledge base***

The technological knowledge base of a firm is defined as the amount of resources that are available for technological development. We compare firms with a medium sized or large knowledge base to firms with a small knowledge base. The knowledge base of a firm can often constraint the number of strategies that are available for technological development. Firms with a small knowledge base often lack the resources that are required for individual development of technology (Bhattacharya and Bloch, 2004). However, imitation can also prove difficult as the use of a technology developed by other firms requires absorptive capacity (Cohen and Levinthal, 1990). Contrastingly, firms with a large knowledge base have both the capacity for individual development and the capacity for imitation due to a large absorptive capacity (Cohen and Levinthal, 1990). However, these firms will often find that other firms have no new knowledge to offer them.

Nooteboom *et al.* (2007) propose to interpret this issue in terms of the optimal cognitive distance between firms. Cognitive distance is created when there are differences in the basic knowledge, perceptions and values of firms. Some degree of cognitive distance yields novel combinations of technology, which is valuable for innovative performance. However, a large degree of cognitive distance increases the absorptive capacity that is required to use a particular technology. Firms attempt to balance the degree of novelty and degree of absorptive capacity that is required, which leads to the selection of an optimal cognitive distance.

Firms with a small knowledge base tend to have a limited absorptive capacity (Cohen and Levinthal, 1990). This means that their optimal cognitive distance is smaller and that they are more inclined to imitate similar firms; firms in the same network have a history of collaboration and tend to have a lower cognitive distance (Gulati *et al.*, 2000). Contrastingly, firms with a large knowledge base have a large absorptive capacity (Cohen and Levinthal, 1990). This means that their optimal cognitive distance is greater and that they are more inclined to imitate firms that offer a large degree of novelty; pioneers or high status firms.

**H10a:** When the technological knowledge base of the firm is *medium sized* as opposed to *small*, the utility of a network strategy *decreases* relative to a pioneer strategy.

**H10b:** When the technological knowledge base of the firm is *large* as opposed to *small*, the utility of a follow-the-pioneer or high status strategy *increases*, while the utility of a network, majority or minority strategy *decreases* relative to a pioneer strategy.

### ***Network structures***

The network structures of a firm are defined as the formal collaborative structures a firm is involved in, such as research consortia, joint ventures, etc. Firms are inclined to imitate those firms that they have contact with (Marsden and Friedkin, 1993; Delios *et al.*, 2008). A high amount of contact can lead to strong legitimization practices (DiMaggio and Powell, 1983), facilitates contact learning (Baum and Ingram, 1998) and the exchange of detailed information (Williamson and Cable, 2003). Thus, the presence of formal collaborative structures increases the benefits from imitation of a network partner (Granovetter, 1985; Gulati *et al.*, 2000). We do not predict an effect on strategies other than a network strategy.

***H11:*** When the firm is involved in a formal collaborative network structure, the utility of a network strategy *increases* relative to a pioneer strategy.

### 3. METHOD

A viable method for the analysis of discrete choices in a random utility framework is discrete choice experiments (DCEs) (Louviere and Woodworth, 1983; Louviere *et al.*, 2000; Otter *et al.*, 2004; Hensher *et al.*, 2005; Adamowicz *et al.*, 2008). In a discrete choice experiment ‘*people’s preferences for goods or services are elicited based on their intentions expressed in hypothetical situations*’ (Flynn *et al.*, 2007, pp.171). Here, DCEs are used to reveal the effect of firm and environmental attributes on the utility of imitation strategies. The technique is based on stated preferences rather than revealed preferences, which enables the study of environments that a firm has not necessarily been confronted with. Another advantage of DCEs is that the internal validity is high compared to methods focused on the outcome of technological development (Ryan *et al.*, 2004).

Although it is possible to use a rating or ranking method for the elicitation of preference, discrete choice experiments offer several advantages. First, rating or ranking methods assume that respondents can rate or rank a number of alternatives *consistently*, which is often not satisfied in practice (Flynn *et al.*, 2007). Second, the rating or ranking scale is usually arbitrary and is often not perceived in the same way by the respondent (Crask and Fox, 1987), which decreases the construct validity of the concepts that are measured (Hensher *et al.*, 2005). Third, differences in response styles between contexts generate scalar inequivalence (Auger *et al.*, 2007). DCEs are a scale free method and do not suffer from these problems (Auger *et al.*, 2007). A disadvantage of using ‘traditional’ DCEs is that they elicit less information from each respondent than rating or ranking systems.

A solution is offered by using a method of Best-Worst Scaling (Finn and Louviere, 1992; Auger *et al.*, 2007; Flynn *et al.*, 2007), also called Maximum Difference Scaling (Szeinbach *et al.*, 1999). This method does not just elicit the best alternative from a respondent (as in traditional DCE), but also the worst alternative. However, an additional assumption has to be made about choice behavior; the respondent is able to select the pair of alternatives with the largest difference in utility. For an elaboration of the statistical properties of best-worst scaling, see Marley and Louviere (2005).

To elicit the choice for an imitation strategy we used discrete choice experiments in combination with best worst scaling. The choice for an imitation strategy was based on conditional demand (Flynn *et al.*, 2007), which implies that we assumed that a firm had already decided to develop a new technology. The DCEs consisted of a number of *choice sets*, which contained a description of the environmental attributes and a number of imitation strategies from which respondents selected the best and the worst alternative. These choice sets were presented to managers of high tech firms in the form of an online survey. The firm attributes were measured in a separate part of the survey. The results of the survey were subjected to two types of analysis in SPSS; a multinomial logit (MNL) models and generalized estimating equations (GEE) models, which are an extension of generalized linear models. The use of two different methods of analysis is useful as both have distinct advantages and disadvantages for the elicitation of choice. The combination of these methods provides some triangulation of the results.

### 3.1. EXPERIMENTAL DESIGN

The experiment – or first – part of the survey consisted of a number of choice sets. These choice sets contained a description of the environmental attributes and a number of imitation strategies from which respondents selected the best and the worst alternative. Each environmental attribute could take two different values. Although this binary specification exclusively allows the estimation of linear relationships, it does provide some advantages; it simplifies the choice task for the respondents and increases interpretability of the results. An example of a choice set is displayed in figure 2.

Environmental attributes						
Rate of technological development	Low rate; product models are replaced every 3-5 years.					
Technological uncertainty	Uncertain; there are multiple development paths for the technology.					
Rate of market development	Low rate; customer preferences are stable.					
Market uncertainty	Uncertain; competitive pressures are high.					
	Pioneer	Follow the pioneer	High status	Network	Majority	Minority
Best strategy	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Worst strategy	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Figure 2: Example choice set.

We used a full factorial design for the experiments. This implies that every possible combination of environmental attributes was included, which resulted in sixteen different choice sets. A full factorial design enables the estimation of the main effects of the environmental attributes and all interaction effects (Hensher *et al.*, 2005), which makes this design preferable to designs that use a smaller number of combinations. We divided the total number of choice sets between two survey versions, or ‘blocks’, to reduce the negative effect of respondent fatigue. The blocks were constructed in such a way that each block contained eight choice sets and had an orthogonal design (i.e. no correlation between the environmental attributes). The order of situations within a block was randomized to rule out order effects (Hensher *et al.*, 2005). In addition, the blocks were systematically randomized between respondents. The choices that were made for the imitation strategies constituted the dependent variable, which we term the ‘choice variable’. Each choice set provided information on each imitation strategy; the strategy was chosen as the best alternative, the worst alternative, or not at all. The choices were then coded 1, -1 or 0, respectively. The content of the choice sets is displayed in appendix 1.

## 3.2. FIRM ATTRIBUTES

The second part of the survey measured the firm attributes, which are displayed in table 2 along with the indicators for the attributes and some descriptive statistics. Two firm attributes were included as control variables; the age and the size of the firm. Several different types of indicators were used. First, the indicator for past imitation strategy was a rating scale that required the division of 10 points between the six imitation strategies. Although a rating scale has its disadvantages (Auger *et al.*, 2007), it allowed the respondent to select a combination of strategies, which is not possible with discrete choice experiments.

Second, the indicator for risk propensity was a combination of three statements that were assessed on a 5-point Likert scale. Some of the disadvantages of Likert scales can be alleviated when they are combined into one measurement scale. To this end, we carried out a confirmatory factor analysis to construct the final indicator. This analysis was based on principal component analysis and a Kaiser criterion. Factor loadings were judged as acceptable when they were higher than 0.7. Although the internal consistency of the final indicator is barely acceptable ( $\alpha=0,677$ ), we have emphasized the measurement of different aspects of risk propensity and the reduction of social desirability rather than highly correlating statements.

Third, several attributes were measured with categories as these attributes tend to involve confidentiality issues and difficulties with obtaining the information required. Although the use of R&D intensity as the single indicator for technological knowledge base offers a rather limited perspective on this concept, it is a reasonable proxy for the amount of resources that are available for technological development. The indicators for firm attributes have been limited intentionally due to the length of the first part of the survey.

## 3.3. SAMPLE

The study was exclusively based on firms located in the Netherlands, to rule out nation specific effects. The firms that were selected are manufacturers of electronic equipment and computers (SBI 2008: 26), manufacturers of electric equipment (SBI 2008: 27) and manufacturers of miscellaneous machines and equipment (SBI 2008: 28). The products that these firms produce include medical equipment, LED lights, propulsion equipment, industrial machinery, consumer electronics and electric components. These sectors were included because these firms have an important technological component, which makes the assumption of conditional demand more acceptable. The selection of firms was based on the trade register of the Chamber of Commerce. Contact was established with firms that:

- o are a manufacturer of products, which implies that service firms such as wholesalers, distributors, repair agencies and consultants were excluded.
- o have a head office in the Netherlands for either the entire firm or a distinct division.

The respondents were the owners or CEOs of the respective firms, or otherwise the manager of the R&D, marketing or technology department. This ensured that the respondents were the ones responsible for actual firm decisions.

Firm attribute	Indicator		Frequency	Mean	SD
Past imitation strategy	Assessment of imitation strategies used in the past (division of 10 points between strategies)	Pioneer		5,0000	3,02515
		Follow the pioneer		1,4118	1,47951
		High status		1,1176	1,36548
		Network		1,6176	2,00022
		Majority		,6471	1,61212
		Minority		,2059	,72944
Innovation strategy	Categories of types of innovations introduced in the last 3 years.	New to the market	19		
		New to the firm	8		
		Only incremental improvements to existing products	7		
Risk propensity	Statements based on Venkatraman (1989) (5 point Likert) ( $\alpha=0.677$ )	Our managers have an inclination for low risk projects.		2,56	1,021
		We believe it is best to develop technology via small incremental steps.		3,24	,923
		My firm typically adopts a cautious "wait-and-see" posture in order to minimize the probability of making costly decisions.		2,76	,987
Technological knowledge base	Categories of % R&D of revenue	0-5%	19		
		5-10%	12		
		>10%	3		
Network structures	Included in formal collaboration structure during last 3 years.	Yes	11		
		No	23		
Age	Number of years since foundation			38,32	28,81
Size	Categories of turnover per year in Euros	<100.00	2		
		100.000 – 1 Million	7		
		1 Million – 5 Million	12		
		5 Million – 50 Million	9		
		>50 Million	4		

Table 2; Firm attributes

### 3.4. DATA COLLECTION

To collect the data we constructed an online survey that consisted of two parts. The survey was preceded by a short explanation of the choice sets and an example choice set. Less knowledgeable respondents could choose for a more extensive explanation. The first part of the survey contained a number of choice sets (see section 3.1) and the second part consisted of the questions that measured the firm attributes (see section 3.2). The survey was administered in Dutch and English to increase the response rate.

A concept version of the survey was assessed by several managers of firms and several other individuals. The criteria in this assessment were that a question did not violate highly confidential information, that the structure of the experiments was clear and that the concepts were interpreted as they were meant to. This feedback resulted in a partially optional, simplified version of the explanation and categorical questions for several firm attributes.

In total, 1472 firms were sent an e-mail invitation for the survey. Of this number, 82 firms received a phone call prior to the e-mail invitation. A reminder was sent to each of the respondents two weeks after the initial invitation. A management report with the most important findings of the study was offered to the firms to raise the response rate.

A total of 34 completed surveys was received, which corresponds to a response rate of 2,31%. Of these surveys 1 was in English, while 33 were in Dutch. Overall, the respondents commented that they had other priorities, which implies that the incentives that were given (i.e. the management report) were not sufficient to persuade managers to invest a significant amount of time and effort into the survey. The low response rate might indicate a selective response of firms that were motivated enough to overcome the cognitive effort involved in completing the survey. This is not problematic as this study specifically emphasizes a high internal validity and a generalization to the underlying theory rather than a high external validity. This implies that the results are only applicable to the specific context of the study and that further study in other contexts is required to allow generalization to other contexts. Even though a selective response rate can result in a common method bias, we took care not to mention that the survey was about imitation (but rather about technological development in general), to avoid a selective response by managers with a preference for imitation.

### 3.5. DATA ANALYSIS

Several different methods of analysis can be used to analyze discrete choices on a best-worst scale. Some authors use a simple counting, average or ratio method of the best and worst alternatives (Cohen, 2009). Although this method provides an approximation of the utility of choice alternatives, it lacks statistical rigor and does not allow for the inclusion of additional explanatory variables (i.e. apart from the DCE), such as the firm attributes. Other authors use more extensive methods of analysis, such as a multinomial logit model (MNL) (Flynn *et al.*, 2007) or a latent class model (Vermunt and Magidson, 2002). These methods allow for the inclusion of firm attributes, which makes these methods a preferable option.

The first method of analysis of this study used the MNL model to investigate the effect of environmental and firm attributes on the utility of the imitation strategies. The ‘choice’ variable was included in the model as the dependent variable. The analysis of the choice variable was based on 1632 observations (34 respondents, 8 choice sets each, 6 strategies per choice set). The independent variables were introduced in three steps. The first model estimated the main effect of an imitation strategy on the choice variable, while all other attributes were assumed to be unobserved in this model. Thus, this model estimated which imitation strategies significantly differ from a pioneer strategy in utility when no other attributes are considered, which essentially assessed the effect of the label of the imitation strategy (i.e. whether it is labeled as high status or network) (Hensher *et al.*, 2005). The second model introduced the environmental attributes in interaction with the imitation strategies, which indicates the effect of environmental attributes on the utility of a particular imitation strategy. The third model included both environmental and firm attributes in interaction with the imitation strategies. All models included two additional control variables; a blocking variable that accounted for the influence of ‘blocking’ the experimental design (i.e. using different versions) and a language variable that accounted for the influence of using two survey languages.

Although the MNL model provided an approximation of the utility of the imitation strategies, several assumptions were made. The most important assumption of MNL is that the error terms are independent and identically distributed (IID). The *independence* term implies that there is no correlation in unobserved attributes - as part of the error term - between observations of choice for the same respondent. The *identically distributed* term implies that unobserved firm attributes do not cause variations in the choice for an imitation strategy (i.e. response homogeneity).

The second method of analysis was generalized estimating equations (GEE), which is an extension of a generalized linear model. GEE can include non-independent error terms, which relaxes the IID assumption. This method supports the repeated measurement of the choices of each respondent by allowing correlation between the error terms of these choices. This implies that a GEE model can lead to more robust results due to a relaxation of the IID assumption. Therefore, we substantiated the first method of analysis with a second method of analysis that used GEE. The relation between the error terms was specified as unstructured, which implies that the relation of the error terms that was estimated by the GEE was not bound by any constraints. The analysis was based on a multinomial distribution of the dependent variable and a cumulative logit link function due to the measurement scale of the choice variable (i.e. ordered categorical). This method of analysis used the same stepwise introduction as the first method; main effects of strategies, environmental attributes, firm attributes.

## 4. RESULTS

### 4.1. MULTINOMIAL LOGIT

The results of the analysis for each multinomial logit (MNL) model are displayed in table 3. The Nagelkerke pseudo R<sup>2</sup> value of model 3 is satisfactory, which implies that the final model is a good predictor of individual choice. The inclusion of firm attributes in the model led to the highest increase in the pseudo R<sup>2</sup>, which implies that the firm attributes offer the largest predictive value. The inclusion of environmental attributes also led to an acceptable increase in predictive value, even though the results for the separate environmental attributes are non-significant at the 0,05 level.

Model	Pseudo R <sup>2</sup>	Attribute	Pioneer	Follow pioneer	High status	Network	Majority	Minority
1	,111	Main effects	0 <sup>a</sup>	-,33	0,08	-,20	<b>-,82**</b>	<b>-1,87**</b>
2	,166	Rate of technological development (H1)	-,64	0,03	,21	0,05	,14	-,22
		Technological uncertainty (H2)	-,43	-,19	-,38	,19	,51	,27
		Technological uncertainty * rate of technological development (H5)	,57	,01	,50	,30	-,89	-,07
		Rate of market development (H3)	-,35	,30	-,49	,40	-,29	,21
		Market uncertainty (H4)	-,28	,29	-,09	-,18	-,15	,45
		Market uncertainty * rate of market development (H6)	,34	-,48	,52	,06	,06	-,35
		Age (C)	-,001	-,005	<b>,01*</b>	,002	<b>-,02**</b>	,006
		Size (C)	<b>,35*</b>	-,11	-,18	-,05	-,13	,04
		Version (C)	-,06	-,32	<b>,87**</b>	0,10	-,11	-,49
		Language (C)	,38	-,39	,09	,75	-,42	-,29

Table 3; Estimates of environmental and firm attributes for the MNL models ( a: reference case, \*: significant at the 0,05 level, \*\*: significant at the 0,01 level).

Model	Pseudo R <sup>2</sup>	Attribute	Pioneer	Follow the pioneer	High status	Net-work	Majority	Minority
3	,268	Rate of technological development (H1)	-,65	,04	,22	,05	,15	-,21
		Technological uncertainty (H2)	-,41	-,20	-,38	,23	,55	,28
		Technological uncertainty * rate of technological development (H5)	,57	,03	,54	,32	-,96	-,10
		Rate of market development (H3)	-,32	,34	-,51	,46	-,34	,24
		Market uncertainty (H4)	-,31	,32	-,09	-,18	-,18	,48
		Market uncertainty * rate of market development (H6)	,28	-,53	,54	,04	,10	-,39
		Past imitation strategy (H7)	<b>,29**</b>	-,007	,15	<b>,44**</b>	-,15	,14
		Innovation strategy: incremental improvement	a					
		Innovation strategy: new to market (H8a)	<b>1,74**</b>	,24	-,45	-,63	<b>-2,07**</b>	,66
		Innovation strategy: new to firm (H8b)	<b>1,01*</b>	<b>1,27*</b>	-,14	-,24	<b>-1,58*</b>	-,42
		Risk propensity (H9)	,32	,18	<b>,64**</b>	<b>-,47**</b>	-,20	-,05
		Knowledge base: 0-5% (H10a)	a					
		Knowledge base: 5-10% (H10a)	,29	-,17	0,45	<b>-,65*</b>	-,32	-,24
		Knowledge base: >10% (H10b)	,58	,33	<b>1,95**</b>	-,21	-,61	<b>-1,90**</b>
		Network structures (H11)	-,17	-,33	,06	<b>1,12**</b>	-,04	-,06
		Age (C)	-,002	-,013	,01	-,01	<b>-,03**</b>	<b>,02*</b>
		Size (C)	,33	,08	-,07	,07	-,10	-,238
		Version (C)	-,07	-,28	<b>0,92**</b>	-,04	-,23	-,411
		Language (C)	<b>2,066**</b>	-1,89	-,54	,94	-,46	,15

Table 3 (continued); Estimates of environmental and firm attributes for the MNL models (a: reference case, \*: significant at the 0,05 level, \*\*: significant at the 0,01 level).

**Model 1; main effects**

Model 1 estimated the main effect of each imitation strategy on the choice variable, which indicates the utility of that imitation strategy relative to a pioneer strategy. Both a minority and a majority strategy have a lower utility than a pioneer strategy, while the other imitation strategies show no significant difference with the utility of a pioneer strategy. One explanation is that firms prefer to base imitation on a *trait* of the firm that uses the technology (i.e. a pioneer, a high status firm or a network partner) rather than on the *frequency* of use of a technology (i.e. majority or minority strategies). Another explanation is that a majority and minority strategy offer less value overall. Even though a majority strategy can offer significant advantages in the form of uncertainty, risk or cost reduction, it also entails that the technology that the firms uses is shared by a large number of firms. This allows little room for differentiation and can make this strategy less attractive. A minority strategy allows the firm to differentiate more than a majority strategy, but offers less risk reduction and no gain in legitimacy. This implies that a minority strategy takes a position in between pioneering and imitation of the majority, which might not be a very attractive strategy.

**Model 2; environmental attributes**

Model 2 estimated the interaction effect between environmental attributes and the main effect of each strategy, which indicates the effect of environmental attributes on the utility of the imitation strategies relative to a pioneer strategy. Even though this model included *observed* firm attributes, the assumptions that had to be made about the *unobserved* firm attributes (IID) have limited the predictive power of the environmental attributes. As a consequence, no support has been found for the effect of environmental attributes in this model (H1-6).

**Model 3; firm attributes**

Model 3 estimated the interaction effect between environmental attributes and the main effect of each strategy and between firm attributes and these main effects, which indicates the effect of environmental and firm attributes on the utility of the imitation strategies relative to a pioneer strategy. As in model 2, no support has been found for the effect of environmental attributes (H1-6).

Some support has been found for the effect of firm strategy. First, the extent to which a particular strategy has been used in the past increases the utility of that strategy in the case of a pioneer and network strategy, which partially confirms hypothesis 7. This implies that recent experience with a pioneer or network strategy provides a guide for future behavior, as a result of embedded routines, capabilities or rules of thumb (March, 1988; Ellison and Fudenberg, 1993; Van Rijnssoever *et al.*, 2012). Second, hypothesis 8a is partially confirmed; the use of a new-to-the-market innovation strategy increases the utility of a pioneer strategy and decreases the utility of a majority strategy, which implies that a pioneer strategy is a valuable strategy for firms that aim to create new-to-the-market innovations, while a majority strategy is not. Third, hypothesis 8b is confirmed; the use of a new-to-the-firm innovation strategy increases the utility of a pioneer and high status strategy and decreases the utility of a majority strategy. This confirms the mechanism proposed by Massini *et al.* (2005) that innovative firms are more inclined to imitate other innovative firms, while non-innovative firms are inclined to imitate the majority of other firms. Fourth, the higher the risk propensity of a firm, the

higher the utility of a high status strategy and the lower the utility of a network strategy, which partially confirms hypothesis 9. This implies that firms that have a high propensity for risk attach more value to a high status strategy and less value to a network strategy, which can be explained by the different risk profiles of these strategies (Banerjee, 1992).

Some support has also been found for the effect of firm capabilities. First, the utility of a network strategy decreases when the technological knowledge base of the firm is medium sized rather than small, which confirms hypothesis 10a. This implies that firms with a small knowledge base value a small cognitive distance (Nooteboom *et al.*, 2007), which is offered by firms in the same network. Second, a large technological knowledge base increases the utility of a high status strategy and decreases the utility of a minority strategy, which partially confirms hypothesis 10b. This implies that firms with a large knowledge base value a large degree of novelty in the technology of the firms that they imitate (Nooteboom *et al.*, 2007); firm with a status of being highly innovative are able to offer this novelty. Third, the presence of a formal collaborative network structure increases the utility of a network strategy, which confirms hypothesis 11. This corroborates the premise that a high amount of contact with a network partner increases the value of imitation of this network partner (Baum and Ingram, 1998).

### ***Control variables***

The control variables have some influence on the results. First, the age of the firm decreases the utility of a majority strategy (model 2 & 3) and increases the utility of a high status (model 2) or minority strategy (model 3). This implies that a majority strategy becomes less attractive once a firm gains more experience in dealing with its environment (Henisz and Delios, 2001). This might be explained by a gradual departure from a majority strategy as a default mode for imitation towards more specific strategies, such as a high status or minority strategy. Second, the size of a firm increases the utility of a pioneer strategy, which can be explained by an increase in resources available for the individual development of technology. Third, the survey version and language affect the utility of pioneer and high status strategies, which points out the importance of controlling for survey version and language.

## 4.2 GENERALIZED ESTIMATING EQUATIONS

The results of the analysis for each generalized estimating equations (GEE) model are displayed in table 4. For this method of analysis no goodness of fit statistics (e.g. AIC, BIC) are available, because the log quasi likelihood function that is required for these statistics cannot be derived when an ordered multinomial logit model is used (i.e. a model with a multinomial distribution and an ordered logit link function) (IBM SPSS Statistics, 2012). No estimation results for firm attributes are displayed as the inclusion of these attributes into the model led to non-convergence of the model, which implies that no model could be specified. The sample was relatively small compared to the number of observations in the study, which might have proven problematic for the estimation of firm attributes (Mancl and DeRouen, 2001).

Model	Attribute	Pioneer	Follow the pioneer	High status	Network	Majority	Minority
4	Main effect	0 <sup>a</sup>	,073	<b>1,15**</b>	,238	-,063	<b>-2,88**</b>
5	Rate of technological development (H1)	<b>,89**</b>	-,24	,11	-,14	,36	<b>-,52**</b>
	Technological uncertainty (H2)	<b>,81**</b>	-,68	-,28	,07	-,21	-,04
	Technological uncertainty * rate of technological development (H5)	-,16	<b>,74*</b>	<b>,73*</b>	,46	<b>-,77*</b>	,23
	Rate of market development (H3)	-,59	,30	-,53	,10	,35	,32
	Market uncertainty (H4)	-,33	,27	,33	-,37	,38	<b>,47**</b>
	Market uncertainty * rate of market development (H6)	,18	<b>-,97*</b>	,20	,32	-,61	-,27

Table 4; Estimates of environmental and firm attributes for the GEE models ( a: reference case, \*: significant at the 0,05 level, \*\*: significant at the 0,01 level).

### Model 4; main effects

Model 4 estimated the main effect of each imitation strategy on the choice variable, which indicates the utility of that imitation strategy relative to a pioneer strategy. A high status strategy has a higher utility than a pioneer strategy, while a minority strategy has a lower utility. The other imitation strategies show no significant difference with the utility of a pioneer strategy. The status of a firm is thus an important predictor of whether the firm is imitated, more so than its involvement in a network (i.e. network strategy), its technological position (i.e. follow-the-pioneer strategy) or the frequency of use of the technology (i.e. majority strategy). The analysis triangulates the result of the MNL model that a minority strategy is less attractive overall.

### ***Model 5; environmental attributes***

Model 5 estimated the interaction effect between environmental attributes and the main effect of each strategy, which indicates the effect of environmental attributes on the utility of the imitation strategies relative to a pioneer strategy. Some support has been found for the effect of environmental change that results from technological development. First, a high rate of technological development increases the utility of a pioneer strategy and decreases the utility of a minority strategy, which partially confirms hypothesis 1. This implies that the urgency for technological development (Damanpour and Gopalakrishnan, 1998) outweighs the more limited opportunities for a competitive advantage in rapidly changing environments (Zhou, 2006). Second, uncertain technological development increases the utility of a pioneer strategy, which rejects hypothesis 2 and contrasts sharply with the predictions in literature (DiMaggio and Powell, 1983; Levitt and March, 1988). It is possible that a pioneer strategy is viewed as a way to postpone the choice for a particular technology; a pioneer strategy requires the internal exploration of technological possibilities, which takes time. Third, the interaction of uncertain technological development and a rapid development rate of technology increases the utility of a follow-the-pioneer and high status strategy and decreases the utility of a majority strategy. This confirms the proposed interaction mechanism of uncertainty and rate of development; firms still value imitation as way to reduce the uncertainty created by the environment, but the sense of urgency created by rapid technological development increases the need for a quick decision. This mechanism decreases the attractiveness of waiting for a majority to support one of multiple development paths.

Some support has also been found for the effect of environmental change that results from market development, though no support has been found for hypothesis 3. First, uncertain market development increases the utility of a minority strategy, which partially confirms hypothesis 4. This implies that a minority strategy is able to reduce some of the market uncertainty created by intensive competition, possibly through the combination with a niche strategy (Greve, 2000). Second, the interaction of uncertain market development and a rapid development rate of the market decreases the utility of a follow-the-pioneer strategy, which contradicts hypothesis 6. This might imply that even though the high rate of development creates opportunities for a competitive advantage (Zhou, 2006), actually pursuing these competitive advantages is perceived as unattractive due to the risk of failure in a highly uncertain environment.

## 5. CONCLUSION & DISCUSSION

### 5.1. CONCLUSION

The study focused on the research question: “*What environmental and firm attributes affect the choice for an imitation strategy in the development of technology by firms?*”. The main purpose of the study was to provide an internally valid empirical foundation for the proposed theoretical framework. To this end, we carried out discrete choice experiments among managers of high tech firms. The choices made in these experiments have been subjected to two methods of analysis; multinomial logit (MNL) models and generalized estimating equations (GEE) models. The latter method relaxes the IID assumption and therefore offers a preferable basis for conclusions. However, the latter method did not allow an estimation of the effect of firm attributes. Even though these separate analyses allow conclusions to be drawn about the effect of firm and environmental attributes, conclusions about the simultaneous effect of environmental and firm attributes should be drawn with caution.

Based on the GEE model we can conclude that the innovative status of firms is the most important basis for imitation overall, though these results were not corroborated by the MNL model. These high status firms serve as opinion leaders for the use of technology by high tech firms (Flynn *et al.*, 1996). Opinion leaders legitimize a technology, which increases its attractiveness (DiMaggio and Powell, 1983). A less attractive option is provided by a minority or majority strategy. This premise is confirmed by the GEE and MNL model for the former and by the MNL model for the latter. This implies that the frequency of use of technology (Haunschild and Miner, 1997) is a less important basis for imitation than traits of the firms that use the technology.

The effects of environmental attributes in the GEE model largely conform to the expectations from contemporary literature on inter-organizational imitation. The predictions in strategic management literature about the effect of the rate of technological development (Damanpour and Gopalakrishnan, 1998) are partially confirmed by the GEE model, while no such confirmation is available for the rate of market development. Although the effect of market uncertainty conforms to the predictions of literature, the effect of *technological* uncertainty in the GEE model contradicts predictions by strategic management literature (Damanpour and Gopalakrishnan, 1998), neo-institutional literature (DiMaggio and Powell, 1983) and literature on organizational learning (Levitt and March, 1988). A possible explanation is that a pioneer strategy is a method of uncertainty reduction in the particular case of *technological* uncertainty; a pioneer strategy requires individual exploration of technology, which allows the firm to postpone the decision for one of the multiple development paths. The interaction effect of uncertainty and rate of development confirmed our predictions in the case of technological development, but not in the case of market development. These differences point out that in the analysis of imitation strategies it is vital to classify environmental change by the source of change.

The estimated effects of firm attributes in MNL model conform to the predictions of literature in all cases, even though some hypotheses are only partially confirmed. The choice for an imitation strategy is

affected by the past experience with this imitation strategy, by the size of the technological knowledge and the network structures of the imitator firm. This confirms some of the mechanisms that are central to literature on organizational learning; the effect of past experience on future behavior (March, 1988), the relation between cognitive distance, absorptive capacity and novelty (Nooteboom *et al.*, 2007) and the advantages of formal collaborative network structures for the imitation of network partners (Baum and Ingram, 1998), respectively. In addition, the effect of novelty related innovation strategies conforms to the mechanism proposed by Massini *et al.* (2005); innovative firms imitate other innovative firms, while non-innovative firms imitate the majority of the population. Finally, the results partially confirm the premise of literature on herd behavior (Banerjee, 1992) that imitation strategies have different risk profiles and that firms act according to their propensity for risk.

## 5.2. DISCUSSION AND FURTHER RESEARCH

This study has contributed to literature on the subject of inter-organizational imitation in several ways. First, the study has integrated several rival explanations for imitation into a single theoretical framework and provided an empirical foundation for this framework. The internal validity of the results is increased with respect to previous studies by the integration of rival explanations for imitation and by employing a method of discrete choice experiments (DCEs) instead of a method focused on imitation outcomes. This addresses the issue of fragmentation in this literature, where each stream of literature provides a limited explanation for imitation by focusing on a subset of motives for imitation. Second, this study has applied a method of DCEs and best-worst scaling to the analysis of strategic firm behavior. Although this method has been applied to marketing studies of product attributes (e.g. Cohen, 2009), the application to strategic choices of firms is new.

Even though the study is able to address some of the issues in contemporary literature, several limitations of the study need to be addressed. First, the predictive power of the models can be increased further by including a wider range of observed attributes into the models, which can result in an improved predictor of individual choice. Some indications for attributes are attributes of the individual manager and context effects. Second, the results of the study are exclusively applicable to high tech firms in the Netherlands. We have specifically focused on internal validity and generalizations to theory rather than generalizations to other populations of firms and other contexts. To increase the external validity, the study should be repeated in other contexts, such as low tech industries and other countries. Third, the study measured discrete firm choices for an imitation strategy, but the connection to actual firm behavior is rather unclear. Future studies should examine to what extent managerial choice translates to actual firm behavior and what the influence of interaction and dialogue is in this process. Fourth, the current study assumed conditional demand for technological development and treated the choice for an imitation strategy as a single choice. The actual choice process will not be as simple as portrayed in the current study. It is likely that firms make a sequence of decisions at different moments in time, where they first decide on the degree of technological development that is required, then on whether it is possible to develop it internally or not and only then consider what firms might be imitated. Future studies should clarify the exact decision making process, possibly by using in-depth interviews. Fifth, this study establishes the preference of firms for particular types of imitation. It is still

unclear whether these imitation strategies lead to actual advantages for firms. Future studies can provide clarity on this issue by examining the outcome of using a particular imitation strategy in the long run.

### **5.3. POLICY IMPLICATIONS**

The study leads to several practical implications for policy that aims to increase the use of particular technologies, such as sustainable energy technologies or efficiency improvements. Firms that have a status of being highly innovative serve as opinion leaders for the use of technology in high tech industries. It is worthwhile to examine which firms are viewed as highly innovative and focus the efforts on these firms. Once these opinion leaders are using the technology, the technology becomes legitimized and the odds of other firms following in line are increased. This mechanism is increased in environments that are characterized by uncertain and rapid development of technology, which is often the case in high tech industries. However, once the rate of development of technology slows down, firms have a decreased sense of urgency for technological development. This decreases the odds of basing their decision on opinion leaders.

The study also leads to several implications for firms that aim to avoid or stimulate imitation of their technology. We have established that the trait of a firm is the most important predictor of imitation rather than the frequency of use of a technology. Thus, the first step in the process is determining what traits are assigned to the firm by other firms in the same industry; whether the firm is perceived as high status, as a pioneer or as a network partner. The second step entails the identification of the types of firms that are likely to imitate the firm, which differs for each firm trait. First, high status firms are most likely to be imitated by firms with a high propensity for risk and a large knowledge base. Second, pioneers are most likely to be imitated by firms that aim to create new to firm innovations. Third, network partners are most likely to be imitated by firms that have experience with network collaboration, that have a low propensity for risk and a small knowledge base. The third step entails the identification of the environment the firms is positioned in and whether this affects the mechanism of imitation. Rapid development of technology on multiple development paths increases the odds that pioneers or high status firms are imitated, even though this is not the case for market development.

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**Appendix 1. Experimental design**

Version	Choice set	Rate of technological development	Technological uncertainty	Rate of market development	Market uncertainty
A	1	Low	Certain	Low	Certain
A	2	Low	Uncertain	High	Uncertain
A	3	Low	Uncertain	Low	Uncertain
A	4	High	Uncertain	Low	Certain
A	5	High	Uncertain	High	Certain
A	6	Low	Certain	High	Certain
A	7	High	Certain	High	Uncertain
A	8	High	Certain	Low	Uncertain
B	9	High	Certain	Low	Certain
B	10	Low	Certain	High	Uncertain
B	11	Low	Certain	Low	Uncertain
B	12	Low	Uncertain	High	Certain
B	13	High	Uncertain	Low	Uncertain
B	14	Low	Uncertain	Low	Certain
B	15	High	Certain	High	Certain
B	16	High	Uncertain	High	Uncertain

Table 5; Experimental design

**Appendix 2. Correlations**

	Innovation strategy	Risk propensity	Technological knowledge base	Network structure
Innovation strategy	1	,44**	,32	,14
Risk propensity		1	,49**	,03
Technological knowledge base			1	-.17
Network structure				1

Table 6; Pearson's correlations (\*: significant at the 0,05 level, \*\*: significant at the 0,01 level).