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# **WHEN THE LEADER FOLLOWS: PERFORMANCE CONSEQUENCES OF LEADER-FOLLOWER IMITATION UNDER ENVIRONMENTAL UNCERTAINTY**

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## **Abstract**

When is imitation of follower actions an effective competitive strategy for a leader? Building on prior work in competitive dynamics and rivalry-based imitation, we propose that imitation is an effective means of staying ahead in winner-takes-all competition in uncertain environments with low information asymmetry. This is because imitating follower actions reduces likely differences in performance between rivals, therefore reducing the likelihood of the follower overcoming the initial advantage of the leader. Furthermore, reduction of difference in competitive positioning between leader and follower serves the same purpose, and both imitation strategies are complementary. These effects of ?action imitation? and ?positioning imitation? are moderated by the degree of environmental uncertainty and by the extent of the leader?s initial advantage. Our theoretical arguments are supported by an analysis of data on head-to-head boat races from the America?s Cup World Series. By illuminating the importance of different kinds of imitation in competitive interaction in uncertain environments, we extend our understanding of competitive dynamics and of the performance consequences of imitation.

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## **INTRODUCTION**

When is imitation of follower actions an effective competitive strategy for a leader?

While strategy researchers have highlighted performance consequences of a leader’s response to challenger moves in competitive interactions (Chen & MacMillan, 1992; Smith et al., 1991), and imitation of a challenger’s actions has been shown to be efficient in preventing performance losses (Ferrier, Smith, & Grimm, 1999), our understanding of leader-follower imitation remains limited.

Rivalry in winner-take-all environments creates a dilemma for the leader: On the one hand, the leader may pursue his strategy without considering the competitor’s path by building on his capabilities and capitalizing on opportunities emerging from changing environments (Teece, Pisano, & Shuen, 1997). This decision risks dethronement if competitors pursue strategies different from the leader’s, and if environmental changes favorable to these strategies take place.

On the other hand, the leader may imitate follower actions in an attempt to maintain relative advantage (Lieberman & Asaba, 2006). In this case, the leader imitates the challenger's path even if the challenger has chosen a poor strategy (Dixit & Nalebuff, 1991:10).

General environmental uncertainty, such as unpredictable changes in the macroeconomic environment and in consumer tastes, affects the likelihood of success of the two strategies while being independent of them. Leaders making imitation decisions over time therefore have to continuously weigh the decision to imitate under uncertainty with the decision not to imitate in order to successfully defend their relative advantage.

Extensive literature has studied environmental and organizational antecedents of imitation (e.g., Lieberman & Asaba, 2006). Different theoretical lenses have helped to examine the motivations behind the imitation decisions, including multimarket contact (Baum & Korn, 1996), competitive response (Chen & MacMillan, 1992; Knickerbocker, 1973), learning in order to reduce uncertainty (Haunschild & Miner, 1997; Henisz & Delios, 2001), gaining legitimacy (DiMaggio & Powell, 1983), or enhancing status (Scharfstein & Stein, 1990). This literature falls into two broad categories: information-based theories and rivalry-based theories of imitation (Lieberman & Asaba, 2006). Studies applying information-based theories show that perceived information superiority of the competitor is an important antecedent of imitation (Brauer & Wiersema, 2012; Semadeni & Asaba, 2010). In contrast, rivalry-based imitation theories regard imitation as a way to maintain competitive parity (Lieberman & Asaba, 2006).

Further work has shown that the dominance of information- versus rivalry-based imitation is influenced by asymmetric information rooted in uncertainty about the success of competitive actions (Asaba & Lieberman, 2011). However, competitors often have the same information about the environmental conditions, and face the same uncertainty since environmental changes are exogenous to their actions (e.g., macroeconomic uncertainty (Campa & Goldberg, 1995;

Huizinga, 1993)). Competitive strategies in rivalry-based competition can be designed to take advantage of such exogenous environmental uncertainty, since uncertainty includes upside potentials (e.g., Bowman & Hurry, 1993), and because competitors may be asymmetrically exposed to it as a result of past competitive interactions. It may therefore be necessary for leaders to consider both competitive interaction and environmental uncertainty<sup>1</sup> in their decisions to imitate in order to successfully defend their relative advantage. Although the antecedents of imitation and its performance consequences have been well studied (Ferrier, 2001; Ferrier, Smith, & Grimm, 1999; Smith et al., 1991), less is known about how leaders leverage imitation strategies in the context of low information asymmetry and varying levels of environmental uncertainty. The existing literature on rivalry-based imitation regards imitative response more as a competitive tool than as a mechanism to deal with environmental uncertainty (Semadeni & Anderson, 2010).

Lieberman and Asaba state that “In ‘winner-takes-all’ environments, rival firms may adopt similar behavior to prevent others from leading the race” (2006: 375). They point out that repeated matching of each other’s moves under low information asymmetries influences total performance outcomes, and that rivalry-based imitation could occur under different levels of environmental uncertainty. Other literature streams argue that exposures to uncertain environments could be limited by imitating a rival’s actions (Miller, 1992), and that imitation may influence the mean and variance of potential performance outcomes (McGrath, 1997), letting exposures to uncertainty potentially become an endogenous factor in strategic interactions.

To test and further extend these arguments, research on the role of environmental uncertainty in rivalry-based imitation and the relative exposure to environmental changes is needed. Because the environmental uncertainty acts as a contingency of the relative performance

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<sup>1</sup> In the following we define ‘environmental uncertainty’ as being exogenous to competitor actions.

of the leader's imitation behavior, and as relative exposures to environmental changes can be influenced by a change in positioning between a leader and a follower, insights into this relationship could enhance our understanding of how imitation in combination with (exogenous) environmental uncertainty can be used as a competitive tactic to defend a leading position.

Building on prior work on competitive dynamics and rivalry-based imitation, we seek to address these questions by introducing a framework that accounts for two related contextual characteristics – environmental uncertainty, which is defined as being exogenous to the competitor's actions, and the chosen imitation strategy which determines the competitors' relative exposure to environmental changes.

We contribute to the literature in the following ways: First, while previous studies predominantly focus on decisions to imitate from the follower's perspective, we focus on the leader's decisions to imitate and argue that imitating the follower can be a strategy that is beneficial for the leader's relative performance. These arguments suggest that a 'follow-the-follower' strategy, a reversal of 'follow-the-leader', can be a viable means of maintaining relative advantage in winner-takes-all competition. Second, we argue that reduction of difference in competitive positioning between leader and follower (i.e., positioning imitation) can serve a similar function to action imitation, and that these two strategies are complementary. Finally, our theory and analysis explore the conditions under which imitating the follower or reducing difference in competitive positioning is most effective. In particular, we reason that environmental contingencies and the extent of the leader's initial advantage moderate these relationships.

In order to test our arguments, we use detailed data on head-to-head sailing competitions (i.e., match races) during the America's Cup World Series 2011-2012. The context offers an ideal setting to test our proposed hypotheses because the nature of match races offers a 'winner-takes-

all' environment with low information asymmetries, allows for fine-grained observation of competitor's moves and performance consequences of rivalry-based imitation, and provides observable, time variant, and exogenous environmental conditions that significantly impact race outcomes.

## **THEORY AND HYPOTHESIS DEVELOPMENT**

### **Competitive interaction and imitation**

Firms engaged in rivalry-based competition often choose homogenous strategies (Lieberman & Asaba, 2006). Yet the imitation literature still lacks a comprehensive understanding of the performance consequences of imitation decisions (Semadeni & Asaba, 2010). Theoretical reasoning from competitive dynamics research predicting outcomes from competitive interactions (Chen & Miller, 2012; Smith, Ferrier, & Ndofor, 2001), combined with insights from work on imitation, could help to improve our understanding of the performance consequences of imitation strategies and extend our understanding of rivalry-based imitation.

The literature on competitive dynamics has pointed out the importance of organizational and environmental factors in explaining competitive actions and performance outcomes (Smith, Ferrier, & Ndofor, 2001), with extant work showing that competitor response time decreases with perceived environmental instability (Smith et al., 1989). However, only a few studies have considered environmental instability as a contingency of the relationship between competitive actions and performance. These show that in new markets, which are characterized as being unstable, the performance of firms is constrained by competitor moves (Katila, Chen, & Piezunka, 2012). In sum, previous studies on competitive dynamics point out the importance of environmental stability in competitive interactions, but theory that ties together competitive moves, environmental uncertainty, and performance is still lacking.

While competitive dynamics research provides numerous valuable insights on the outcomes of competitive interactions, several questions remain. First, rivalry-based imitation can be a consequence of uncertain environments (Lieberman & Asaba, 2006), but it is not clear how environmental uncertainty affects the outcomes of leader-follower imitation. Second, previous competitive dynamics research has operationalized the unpredictability of unstable environments using multidimensional, largely subjective measures, and in a rather static way. However, uncertainty might be the result of specific exogenous influences and, hence, be the same for all competitors. As a change in environmental conditions might alter the benefits of imitating competitor actions, it is important to improve our understanding of how such volatile conditions are related to the performance consequences of competitive interactions.

### **Competitive moves, volatile environments, and performance**

Several empirical studies have pointed out that high-velocity environments provide opportunities to achieve superior performance (e.g., Davis, Eisenhardt, & Bingham, 2009; Thomas & D'Aveni, 2009; Tushman & Anderson, 1986). Research in this stream has also worked to disentangle the multi-dimensional construct of environmental dynamism by studying how different dimensions of environmental dynamism influence the relationship between organizational structure and performance (Davis, Eisenhardt, & Bingham, 2009). The results show that these dimensions have differing effects on performance, and suggest that the effects of separate dimensions of environmental dynamism, such as unpredictability or the rate at which opportunities emerge, should be explored in order to bring new insights into the field of competitive strategy.

Strategic management often uses the term 'uncertainty' to refer to the unpredictability of environmental or organizational factors that influence performance (Miles & Snow, 1978; Pfeffer

& Salancik, 1978). Strategy scholars argue that strategic moves can be used to mitigate risk associated with environmental uncertainties and so reduce exposures to uncertainty (Miller, 1992, 1998). Firm exposure to changes in environmental conditions which are exogenous to a firm's action can be influenced by several strategic actions, like postponement, imitation by following the leader, or by strategic flexibility (Miller, 1992). Others argue that imitation efforts by competitors reduce the mean and the variance of potential performance outcomes (McGrath, 1997). In this view, the outcomes of uncertain contingencies can be shaped by strategic actions in the firm's favor.

Overall, the literature on strategic management under uncertain environmental conditions provides valuable insights on how decision makers can use strategic actions to improve performance under such conditions. However, the literature still leaves several remaining questions regarding a leader's decision to imitate or not to imitate in dynamic and unpredictable environments unanswered. First, although a motivation for rivalry-based imitation can be to reduce risk (Lieberman & Asaba, 1996), risk that is related to the unpredictability of performance outcomes due to environmental changes (i.e., environmental uncertainty) has not been tied to imitation decisions nor to competitive moves and relative positioning. Second, 'waiting' for uncertainty to resolve over time is not always an option. Previous studies have highlighted that in some environments 'wait-and-see' is likely to lower performance, since all involved competitors are in a race and try to be as fast as they can to stand still relative to competitors (Barnett & McKendrick, 2004; Derfus et al., 2008). In competitive environments, rivals may also believe that they cannot afford to wait until uncertainty is resolved and would rather take any action (Porter, 1980). Winner-takes-all environments may exhibit very similar effects, since rivals are actively engaged in trying to lead the race ahead of their competitors (Lieberman & Asaba, 2006). Exogenous environmental contingencies and endogenous change of relative uncertainty

exposures may become part of the strategic interactions determining the winner of such a race. Considering the dynamics of environmental conditions and the unpredictability of the future when making imitation decisions may therefore be a successful mechanism for maintaining a leader's relative performance.

### **Staying ahead by imitating the follower, reducing difference in positioning, and limiting the downsides of volatile environments**

The extent to which the leader imitates the actions of the follower may be related to the likelihood of the leader staying ahead. A second aspect of competitive interaction that could also affect the performance outcomes is the difference between leader and follower positioning. In contrast to the extent of imitation of follower actions, which captures similarity between trajectories of leader and follower actions over time, this second construct (i.e., positioning imitation) captures the average difference between leader and follower positioning during the competitive interaction, and therefore describes the similarity between their average competitive positions. Hence, competitors can follow an imitation strategy and have the same average positioning, or they can imitate while positioning themselves differently, and vice-versa.

A simple example may help to clarify the difference between the two constructs. Consider two markets, A and B, for different kinds of products in which two firms compete. At the start of competition the leading firm produces four products for market A and six products for market B, while the follower firm enters the markets with two products for market A and one product for market B. Now suppose that in the next period the follower introduces two new products for market A, raising its total number of products in that market to four. The leading firm may choose to imitate this action and also introduce two more products to market A. In this case, the competitive trajectories of the two firms would be identical, but there would be a difference in

average positioning over the two periods equal to two goods in market A and five goods in market B. In contrast, if the follower had entered both markets with the same number of products as the leader and the leader again chose to imitate the follower's actions, there would be no difference in either the average positioning between the rivals or in their competitive trajectories.

Our theoretical framework will argue that both imitating competitor's moves and imitating their positioning are related to the likelihood of the leader staying ahead. Based on similar theoretical mechanisms, the two different constructs affect the likely difference between leader and follower performance outcomes, are complementary imitation strategies and, therefore, influence the likelihood of the leader remaining in the lead.

In order to develop our theoretical mechanisms, we complement insights from competitive dynamics research with insights from the literature on exposures to environmental uncertainties. We argue that imitation increases the likelihood of a leader remaining ahead by neutralizing potential performance differences arising as a consequence of the (aggressive) moves of the follower. Similarly, a reduction in the difference between leader and follower positioning increases the similarity of leader and follower exposures to environmental changes and therefore decreases the likelihood of potential performance differences. We further argue that the performance outcomes of decisions to imitate follower actions and positioning are contingent on two different factors: environmental uncertainty and the extent of the leader's initial advantage.

As our theory explains relative performance in winner-take-all environments, we differ from previous literature which focuses on explaining performance outcomes like firm value or risk. Since the direct effects of both action and positioning imitation on the probability to successfully defend a leader's relative performance is likely to be moderated by environmental contingencies, we will in the following first discuss these direct effects.

**Direct effects of action imitation and positioning imitation.** In winner-takes-all competition between a leader and a follower the leader's main objective will be to stay ahead (Lieberman & Asaba, 2006). If the competitive conditions are such that the leader can easily observe and successfully imitate the actions of the follower, an imitation strategy will result in similarity between leader and follower competitive trajectories. As similar competitive trajectories are likely to yield similar performance, even in uncertain environments, a leader successfully imitating the actions of his follower is likely to remain in the lead because he neutralizes potential performance differences arising as a consequence of the (aggressive) moves of the follower.

By contrast, a leader taking the decision not to imitate the actions of the follower is likely to have a competitive trajectory that differs significantly from that of the follower. Since different competitive trajectories are likely to result in different performance, the leader in this case runs the risk of the follower's set of actions outperforming his own. If this performance difference is large enough the lead will be lost.

A similar mechanism is at work when a leader chooses a strategy that leads to difference in average positioning between the leader and the follower. The likely difference between performance outcomes of the leader and the follower is then minimized when the rivals have the same average positions over the course of the competition – a high degree of positioning imitation. The greater the imitation of follower positioning by the leader, the higher the likelihood of the leader staying ahead of the follower, due to a lower likely difference between leader and follower performance outcomes.

Hypothesis 1a. In winner-takes-all competition, the likelihood of staying ahead of the follower is higher when the leader imitates *the follower's actions*.

Hypothesis 1b. In winner-takes-all competition, the likelihood of staying ahead of the follower is higher when the *leader imitates the follower's positioning*.

**Interaction effect between action imitation and positioning imitation.** We have argued above that the extent to which the leader imitates the actions of the follower is positively related to the likelihood of the leader staying ahead as greater action imitation increases the similarity between leader and follower competitive trajectories, therefore decreasing the likely difference between leader and follower performance outcomes. We also argued that positioning imitation could be a means of reducing the risk of getting dethroned. Since these decisions are independent, the leader is able to choose both the extent to which he imitates both the actions and the positioning of the follower.

Suppose that similarity between leader and follower performance outcomes increases not only with the similarity between their competitive trajectories, but also with the similarity between their average competitive positions. The likely difference between performance outcomes of the leader and the follower is then minimized when the rivals have both identical competitive trajectories and the same average positions over the course of the competition. An increase in action imitation when positioning imitation increases will therefore reduce the likely performance difference between competitors by more than the same increase in action imitation when positioning imitation does not increase.

Hypothesis 2. The greater the extent of positioning imitation, the greater is the effect of action imitation on the likelihood of the leader staying ahead of the follower.

**The moderating effect of environmental uncertainty.** Volatile environmental conditions can lead to uncertainty over the future state of the environment. Though competitors may prefer

to wait for uncertainty to resolve before making a decision, to avoid standing still while other competitors take action, they have to choose a trajectory that they believe will be beneficial. The unpredictability of environmental conditions can therefore influence the strategic efforts these competitors make (Miller, 1998).

The degree of uncertainty in the competitive environment is likely to affect the effects of a leader's imitation of follower actions on performance. This is because a greater degree of uncertainty regarding the payoff to following any given competitive trajectory will increase the range of possible differences in performance between trajectories chosen by the leader and the follower for all trajectory pairs apart from those which are identical, i.e. those arising from perfect imitation of follower actions by the leader or vice-versa. Volatile environmental conditions lead to asymmetrically gains or losses from a change in environments. The less similar the leader and follower competitive trajectories, the greater the increase in the range of possible performance differences as a result of greater environmental uncertainty is likely to be.

Putting identical bets on the future under unpredictable environments can lead to identical large positive or negative outcomes for all competitors (Lieberman & Asaba, 2006). If different bets are placed then performance outcomes differ between the competitors, leading to performance differences. In an uncertain environment, a leader who decides not to imitate the follower's actions increases the risk of getting dethroned. In environments of greater uncertainty a greater degree of action imitation is likely to reduce performance differences between competitors by a larger extent than it would in less uncertain environments. Therefore, the greater the degree of environmental uncertainty, the greater is the increase in likelihood of the leader remaining ahead due to an increase in the extent of leader action imitation of follower actions.

This moderating effect of environmental uncertainty also applies to the effect of positioning imitation on the likelihood of the leader staying ahead. With high degree of

uncertainty, a smaller difference in competitive positioning reduces the probability of different performance outcomes due to different exposures to volatile environments by more than when uncertainty is low, and therefore increases the likelihood of staying ahead to a greater extent.

Hypothesis 3a. The greater the degree of environmental uncertainty, the greater the effect of action imitation on the likelihood of the leader staying ahead of the follower.

Hypothesis 3b. The greater the degree of environmental uncertainty, the greater the effect of positioning imitation on the likelihood of the leader staying ahead of the follower.

*The moderating effect of the leader's initial advantage.* The extent of the leader's initial advantage over the follower is likely to be positively related to the likelihood of the leader being victorious (Ferrier, Smith, & Grimm, 1999; Miller & Chen, 1994), unless the advantage impairs the leader's decision-making through complacency or arrogance. However, alongside this rather trivial direct effect, initial advantage will also likely affect the relationship between imitation of follower actions and the likelihood of the leader remaining ahead of the follower.

As action imitation increases the similarity between leader and follower competitive trajectories and therefore performance outcomes, a given increase in the extent to which the leader imitates the actions of the follower will reduce the difference in performance outcomes between leader and follower by a given amount. Whether or not this reduction in performance difference materially affects the likelihood of the leader staying ahead depends on the initial performance advantage of the leader over the follower.

Suppose that the leader's initial advantage over the follower is miniscule, so that nearly any superiority in follower performance is likely to be sufficient for the lead to change hands. In such a case even near-perfect imitation of follower actions while maintaining very similar competitive positions may be unable to preclude the possibility of the follower outperforming the

leader and going in front, so an increase in action imitation or positioning imitation to anything but the highest level possible is unlikely to have much effect on the likelihood of the leader staying ahead.

By contrast, suppose that the leader has a large initial advantage. In this case an increase in the extent of the leader's imitation of follower actions or an increase in positioning imitation from most base values will act as an effective means of reducing the risk of a performance difference which is sufficiently large for the lead to change hands.

Hypothesis 4a. The greater the initial advantage, the greater the effect of action imitation on the likelihood of the leader staying ahead of the follower.

Hypothesis 4b. The greater the initial advantage, the greater the effect of positioning imitation on the likelihood of the leader staying ahead of the follower.

## **DATA AND METHODS**

### **Study Context**

We test our hypotheses using data from two boat competitions (i.e., match races) during the America's Cup World Series 2011-2012 (ACWS). There are several reasons why match racing is an appropriate context to test our theory: First, match races are winner-takes-all environments in which leader and follower compete for the same outcome; 'competition' is highly promoted in those environments (Lieberman & Asaba, 2006) and 'cooperation' or 'collusion' is not an option.

Second, competitors in match races have similar size and resources and are therefore direct rivals (Chen, 1996; Lieberman & Asaba, 2006). The competitors sail on one-design boats with a fixed crew size and a maximum crew weight per person. The ACWS therefore offers a

setting where performance differences are based on the team's ability to handle the technology in a changing environment, and on the decisions made during the sailing race.

Third, upwind legs in sailboat racing provide the advantage of observing reversed 'follow-the-leader' strategy (Dixit & Nalebuff, 1991: 10). The beginning of the upwind leg and the relative position between competitors is defined once they round the leeward mark, and the leg ends when the boats reach the windward mark (see Figure 1). Since a sailing boat cannot directly sail in the direction from which the wind is blowing (the windward mark is positioned into wind direction from the leeward mark), it has to sail a zig-zag course. Tacking is a maneuver during which the front of a boat turns through the wind until the wind blows from the opposite side of the boat to the one from which it was blowing before, and the pattern of the course sailed by a boat is influenced by where and how often it performs tacking maneuvers. The decision to tack is influenced by the competitor's position: In order to keep control of the follower, the leading sailboat can copy the moves of the following boat (i.e., tack when the follower tacks) and can do so even if the following boat sails a poor strategy. Performance consequences of such a reversed 'follow-the-leader' strategy can be tracked due to observable relative position at the end of each upwind leg. Detailed positional data allow us to observe the pattern of multiple competitive moves of the leader relative to the follower over time. The context therefore allows us to address a critical gap in the literature on rivalry-based imitation theories by tying performance consequences to imitation decisions (Semadeni & Anderson, 2010) and by studying longer term effects of leader-challenger interaction (Ketchen, Snow, & Hoover, 2004).

Fourth, our theoretical model emphasizes the environmental contingencies that influence the outcomes of imitation strategies: The success of positioning relative to the competitor is influenced by contingencies that are exogenous to the decisions being made and by the relative exposure to environmental changes. The improvements in relative performances in sailboat races

are strongly influenced by changes in wind direction in combination with the positioning of the boats on the course, such as distance (Perry, 1984: 182) and the angle between the boats and the windward mark (Willis & Doerr, 1993: 111). Volatile wind directions can lead to uncertainty over the future wind directions (Bethwaite, 1996; Walker, 1991). Wind shifts, changes in wind direction that are sustained over time, will influence the success of chosen strategies of the leader. The wind direction is independent of the decisions being made and works as an exogenous source of uncertainty in our setting. Both competitors have the same information about the environmental setting, and, therefore, the information asymmetry between them is low. To study the role of the environmental contingencies, detailed wind data allow us to observe wind shifts and volatility. Our context therefore facilitates the measurement of the construct of environmental uncertainty and helps us to address the problem of objectively assessing environmental uncertainty in testing rivalry-based imitation theories (Lieberman & Asaba, 2006).

Finally, as with other sports, match racing has pre-defined boundary conditions and rules which are enforced immediately after an incident occurs. Sports offer advantages of a controlled 'living laboratory' when studying relative advantage between competitors (Day, Gordon, & Fink, 2012). Such a setting reduces the role of institutional environments as influencing factors on performance outcomes and assures the availability of decision options between rivals over time (Holcomb, Holmes, & Connelly, 2009). Recent studies show that sport settings are useful in advancing our understanding of a broad variety of problems in management and organization, such as the competitive rivalry (Kilduff, Elfenbein, & Staw, 2010; Sirmon, Gove, & Hitt, 2008), risk taking (Lehman & Hahn, in press; Lehman et al., 2011), resource management (Holcomb, Holmes, & Connelly, 2009), status (Washington & Zajac, 2005), or tacit knowledge and team work (Berman, Down, & Hill, 2002). Since sailing match races offer observable imitation

decisions, changes in environmental contingencies, and performance outcomes, the context satisfies the conditions required to study rivalry-based theories of imitation.

## **Data**

The data we use to test our hypotheses come from the match race pairings during the America's Cup World Series 2011-2012. The series is a professional sailing circuit taking place at six different international venues. The ACWS is sailed on one-design 45-foot long catamarans and is launched in order to gain experience with multihulls for the 34<sup>th</sup> America's Cup.

Each of the six events of the ACWS consists of a (two-boat) match-race competition and a fleet-race competition (i.e., more than two boats racing against each other at the same time). The results of the fleet races, which take place before the match-race competition, are used for seeding the pairings for the match-race qualifiers that lead into the subsequent finals. To win a match, a team has to win a certain number of races in a single paring. After succeeding in the final, the winner is the match race champion of the event. The overall champion of the AC World Match Races Series is decided by the cumulative match-race scores over all six events taking place in Cascais (Portugal), Plymouth (UK), San Diego (USA), Naples (Italy), Venice (Italy) and Newport (USA).

A match race of the ACWS usually takes about 15-20 minutes. The distance between the marks the boats have to sail around depends on the strength of the wind, with the race committee defining the positioning of the marks and the boundaries of the course depending on the wind direction, the wind speed, and the shore lines. Once the boats have started, they sail a short sprint to Mark 1 before the up- and down-wind legs begin (cf. Figure 1). The boats have to sail around the marks in order, but can chose their course way between marks. The leeward mark (Mark 2 and 4) and the windward mark (Mark 3 and 5) both take the form of a gate between two buoys so

that the boats can sail left or right once entering the gate, thus choosing their course towards the next mark. The boats have to remain within the boundaries of the course at all times during the race, with time penalties given out to boats that fail to do so.

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Figure 1  
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The America's Cup Race Management offers the streaming data of the ACWS sailing races in a publically accessible format. The internet platform offers the opportunity to download the data and also to watch the live races as well as past races via virtual spectator software. The data consist of various instrument readings from boats as well as live race information. Three types of information are included: First, GPS data of the sailing boats, the position of the marks that define the course to be sailed, and the boundaries that define the maximum area to be sailed in. Second, information about the wind direction and the wind speed. Third, chatter files that offer information on the boats sailing against each other, the start timing, the mark rounding order and time including the seconds behind the leader, the umpire decisions including penalties. For our purposes, we reduced the GPS- and wind-data format from 5 data points to one data point per second.

Our unit of analysis is the upwind leg. During the upwind leg a leader has the choice to imitate the follower's course; if the follower tacks and changes its heading, the leader can match this move. If a competitor decides to reverse the last change in heading it can subsequently tack back. However, during each tacking maneuver a boat loses speed, hence the decision to tack is costly and not completely reversible.

Over a total of 6 events, there were 79 match races between pairings of the 11 teams participating in the competition. Of these, we drop from our data two races that were abandoned

during the match and restarted, and one more in which one of the competitors withdrew from the race due to technical problems. Two more races are excluded from our sample as data on boat GPS coordinates and wind direction for these races are not available from the America's Cup website. The total number of races in our sample is therefore equal to 74.

Each race contained between 1 and 3 upwind legs, resulting in a total of 151 observations. Three of these observations are excluded due to implausible wind data which prevent us from constructing the necessary variables, leaving us with 148 observations in our final sample.

### **Dependent variable**

**Leader wins.** Our dependent variable is whether or not the boat that was ahead at the start of the upwind is the first to round the windward mark, thus remaining in the lead at the end of the leg. We operationalize this measure as a binary variable equal to 1 if the boat leading at the start of the upwind was recorded as being the first to round the windward mark in the official race chatter file, and equal to zero if the follower rounded the windward mark first instead.

### **Independent variables**

**Action imitation.** We operationalize action imitation as correlation between the compass headings of the leading and following boats, with the heading of the leading boat being lagged by one second to leave a sufficient window of time for the leader to observe follower actions and react to them. While one second may seem like a very short time for a competitive reaction to take place, in our context follower actions are easily observable and are a major focus of the leading team helmsman's attention, while both leader and follower teams consist of highly experienced sailors equally able to execute the full range of competitive moves. This variable

takes the value of 1 if the leader's lagged changes in heading match exactly those of the follower, a value of -1 if they are opposite, and a value of 0 if there is no relationship between them.

**Positioning imitation.** To measure the difference between leader and follower positioning during the upwind, we take the absolute value of the difference between their average position with respect to course boundaries over the upwind leg. This variable then takes a value of 0 if both boats have the same average course position during the upwind and decreases with any difference in average positioning.

To capture the average positioning on the course of the leader relative to the follower, we first calculate the average distance of each rival from both sides of the course using data on the GPS positions of the boats and of the course boundaries. For each boat, we then calculate the difference between its average distance to the boundary on its right and left sides, capturing the average position of the boat on the course. Finally, we subtract the average position of the follower from that of the leader to produce a measure of their relative positioning, and take the negative of absolute value of this measure, so that an increase in the measure corresponds to an increase in the degree of positioning imitation.

Figures 2 and 3 illustrate the differences between the constructs of action imitation and positioning imitation in our context. Figure 2 shows that when choosing a high action imitation strategy the leading boat A can maintain either a low or a high degree of positioning imitation of boat B. Meanwhile, Figure 3 presents possible trajectories for a leading boat A when it chooses a low extent of action imitation, with positioning imitation being very high in the left panel, while being low in the right panel.

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Figures 2 and 3 about here  
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**Uncertainty.** We follow prior work on the effects of uncertainty (e.g., Folta & O'Brien, 2004; Oriani & Sobrero, 2008) by using a Generalized Autoregressive Conditional Heteroscedasticity (GARCH) model (Bollerslev, 1986) to generate a measure of uncertainty regarding wind direction which takes into account trends and cyclical patterns in the data. Specifically, we estimate a GARCH (1,1) model which appears to provide a good fit for the behavior of many asset prices (Folta & O'Brien, 2004). Similar models have also been used in weather forecasting to predict wind fluctuations (Cripps & Dunsmuir, 2003). Following Oriani and Sobrero (2008), we additionally include an autoregressive dependent variable term capturing wind direction in the previous second in our specification to improve model fit and convergence. Our uncertainty measure is calculated as the absolute percentage difference between the forecast of wind direction at a given point in time produced by the model and the true wind direction, in the same manner as the measure used by Oriani and Sobrero (2008). However, as we have observations on wind direction for every second of each upwind leg, the uncertainty measure that we use in the analysis is the average value over the upwind leg of the forecast error described above.

**Initial advantage.** We take the distance that the leader is ahead of the follower when the follower has rounded the leeward mark as our measure of the initial advantage. As the effective distance that a boat needs to sail to the next mark is highly dependent on wind direction, this distance measure is calculated as the distance between the rival boats with respect to the direction from which the wind is blowing (see Figure 1). This distance measure is calculated in the race representations available on the virtual spectator software.

## **Control variables**

**Leader uncertainty exposure.** We control for the extent to which the leader's average course position left him exposed to unpredictable changes in wind direction by taking the absolute value of his average course position. This measure is equal to 0 if the leader was on average an equal distance away from both sides of the course and therefore stood to gain or lose least from a change in wind direction, and increases if the leader was on average closer to one side of the course than to the other.

**Leader penalty.** Either competitor in the race may be penalized for sailing beyond the course boundaries, or for a number of other rule violations. If penalized, the boat in question must slow down and allow the competitor to gain a distance of two boat lengths. As the serving of a penalty provides a clear advantage to the competing boat, we control for instances in which the leading boat was penalized during the course of the upwind leg. This variable takes the value of 1 if the leading boat received a penalty during the course of the upwind and a value of 0 if it did not.

**Same initial trajectory.** We control for whether or not the leader and follower had the same initial competitive trajectory at the start of the upwind using a binary variable that takes the value of 1 if both leader and follower decided to round the leeward mark in the same direction and a value of 0 if they did not.

**Leader experience.** As experience of the leading boat's helmsman in previous tournaments is likely to be related to his ability to take the appropriate competitive actions during the race, we use a dummy variable to capture the helmsman's experience of racing in prior America's Cup competitions. This variable is equal to one if the helmsman of the leading boat has previously participated in at least one prior America's Cup series, and 0 otherwise.

**Difference in seeding for match races.** To control for performance differences reflecting some advantage of one boat over another during a particular event, we include a variable

capturing the difference between the seeding of the leader and follower boats for the match races. The seeding is determined by the results of a number of fleet races which include all competing boats and which take place before the match races at the same location.

**Leader and follower performance to date.** As the racing teams are likely to learn from their prior results, we include a measure for both leader and follower performance to date in our analysis. For each of the boats this measure is equal to the number of match races won as a proportion of the races that that boat had participated in during the ACWS before the current race.

**Last upwind of race.** It has been argued that competitive behavior in the final competitive interaction of a series might differ significantly from that practiced at other points in the course of the competition (e.g., Lehman et al., 2011). We therefore include a binary variable taking on the value of 1 if the current upwind is the last upwind of a race and 0 otherwise to control for the influence of such effects on both competitive actions and performance outcomes.

**Race number.** We control for potential learning of teams from observation of others racing prior to them by including a variable that captures the position of the race in that day's racing order.

**Event number.** Finally, we control for the effects of team learning over the course of the series by using a measure of the position of the event in the series in our empirical model.

## RESULTS

### Descriptive statistics

The summary statistics of the variables used in our analysis are presented in Table 1 below. The boat that is leading at the start of the upwind leg wins the leg 91% of the time. The extent of action imitation and positioning imitation varies significantly between observations.

This is also true for environmental uncertainty and initial advantage, although the former's range of variation is much smaller in absolute terms.

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Table 1 about here  
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The correlations between our variables are presented in Table 2. As very few variables have a correlation greater than 0.2 and as the highest correlation is 0.48, it seems that multicollinearity is not a major concern in our estimation. This impression is supported by the fact that the variance inflation factors in our estimated models are generally low, well below 10, with the exception of the last estimated model which includes all hypothesized interaction terms and therefore does appear to suffer somewhat from multicollinearity.

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Table 2 about here  
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### **Regression results**

To test our hypotheses we estimate logit regression models with heteroscedasticity-robust standard errors clustered by leading boat. The estimation results are presented in Table 3.

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Table 3 about here  
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We first estimate a model including only our control variables. Models 2-4 then test hypotheses 1a and 1b by adding action imitation and positioning imitation to the set of explanatory variables, first individually, and then together. The estimated coefficient on action imitation is positive and significant, and remains so throughout all specifications in which it is

included, providing strong support for hypothesis 1a. Hypothesis 1b is also supported as the estimated coefficient on positioning imitation is positive and significant in the vast majority of our model specifications.

In order to evaluate the substantive effects of imitation and difference in positioning on the likelihood of the leader staying ahead, we follow suggestions in recent literature (e.g., Hoetker, 2007; Zelner, 2009) and plot the marginal effects of these variables across a range of their possible values in Figure 2, panels a and b. The marginal effects presented are estimates of the average marginal effect from model 4, in which both direct effects are included, with values of other covariates allowed to take on their sample values for all observations. The lines above and below the estimated marginal effects on the graph represent 95% confidence intervals.<sup>2</sup>

Panel a of Figure 4 shows that the marginal effect of action imitation is significant across the whole range of its values, but appears to be larger at lower base values than at higher ones. For example, an increase in action imitation from a base of -0.5 appears to increase the likelihood of the leader staying ahead by around 30 percentage points, while a similar increase from a base value of 0.5 raises the probability of staying ahead by about 10 percentage points.

In contrast to the marginal effect of action imitation, which is always significant, the marginal effect of positioning imitation is significant only when the leader and follower are no more than 200 meters apart, as can be seen in panel b of Figure 4. The size of the marginal effect decreases somewhat as the base value of positioning imitation becomes larger, going from about a 20 percentage point increase in likelihood of leader winning to around 10 as the base value increases from -200 to zero.

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<sup>2</sup> While we follow the suggestions for the graphical representation of marginal effects and interactions made by Zelner (2009), we are unable to use simulation methods to generate these figures due to our use of robust, clustered standard errors in estimation. Instead, we calculate marginal effects using the standard methods as implemented in Stata's 'margins' command.

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Figure 4 about here  
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To test hypothesis 2, we add the interaction between action imitation and positioning imitation in model 5. The estimated coefficient is positive and significant as predicted, and remains so in nearly all other model specifications. Hypothesis 2 is therefore supported. Figure 5 presents a plot of this interaction effect which shows how the marginal effect of action imitation varies when positioning imitation takes on low (one standard deviation below the mean), mean, and high (one standard deviation above the mean) values. The figure suggests that increasing action imitation from a low base value has a higher impact on the likelihood of staying ahead when positioning imitation is high than when it is low, in line with our expectations. However, it appears that an increase in action imitation from a high base value is more effective when the positioning imitation is low than when it is high, although this difference is much smaller than the difference in marginal effects when imitation is increased from a low base value. Overall, the figure appears to support our hypothesis, although it raises the possibility that action imitation and positioning imitation are complements in reducing the likelihood of dethronement when action imitation is relatively low while being substitutes for one another when action imitation is relatively high.

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Figure 5 about here  
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Models 6 and 7 test the moderation effects of environmental uncertainty proposed in hypotheses 3a and 3b. One of the moderating effects appears to be significant when they are introduced individually, but both have signs opposite to those predicted. When included

simultaneously however, as in model 10 and in other models not reported, the estimated coefficients on these interaction terms are not significant. Hypotheses 3a and 3b are therefore not supported by our analysis. The suggestion in models 6 and 7 that the moderating effect of environmental uncertainty is opposite in sign to our predictions is rather puzzling and we discuss it in more detail below.

Hypotheses 4a and 4b, proposing that the effects of action imitation and positioning imitation are moderated by the extent of the leader's initial advantage, are supported by the results of models 8 and 9, as the interaction effects are significant and of the predicted sign. Panels c and d of Figure 4 illustrate the marginal effects of action imitation and positioning imitation when initial advantage is low, at the sample mean, and high. When initial advantage is low, the marginal effects of action imitation and positioning imitation are not significantly different from zero at a 5% level of significance, as argued in our hypotheses. However, these marginal effects are significant and match our predictions at moderate or high levels of initial advantage, being greatest when initial advantage is high and the base values of action imitation and positioning imitation are low. These moderating effects remain significant in model 10, providing further support to our hypotheses.

## **DISCUSSION**

This paper has sought to answer the question of when imitation of follower actions can be an effective competitive strategy for a leader. Unlike most prior perspectives on imitation, which have focused on imitation of leaders by followers, we argue that 'follow-the-follower', a reversal of a 'follow-the-leader' strategy, is an effective competitive strategy for a leader in winner-takes-all competition when the environment is uncertain. Building on Lieberman's and Asaba's (2006) discussion of rivalry-based imitation theories, our aim was to understand factors influencing the

imitation-performance relationship in uncertain environments, and, in particular, how imitation of follower actions and competitive positioning can be used as mechanisms for dealing with uncertain environmental conditions.

Our findings suggest that, in the context of winner-takes-all competition, a leader who imitates the follower's actions is likely to stay ahead in the race. However, imitation of competitive positioning is also important, as the likely difference between leader and follower performance appears to be smallest when the rivals not only take the same actions but also share the same competitive position. These effects are moderated by the extent of the leader's initial advantage in such a way that a leader with a greater initial advantage stand to benefit more from using these strategies.

### **Theoretical contribution**

We contribute to competitive dynamics research by extending our understanding of the role of (exogenous) environmental contingencies on the performance outcomes of competitive interactions over time. While previous work has considered environmental factors (for a review see: Smith, Ferrier, & Ndofor, 2001), these have been treated more as a controls than as an important part of the competitive mechanisms used to enhance or defend performance. By focusing on leader strategies over the course of a competitive interaction instead of looking at specific imitation decisions, we also contribute to the literature by taking a longer term view of leader-challenger interaction in dynamic environments.

Our study also contributes to the recent literature stream on imitation (Asaba & Lieberman, 2011; Brauer & Wiersema, 2012; Lieberman & Asaba, 2006; Semadeni & Anderson, 2010). This work has pointed out the relevance of environmental uncertainty for rivalry-based imitation and discussed the effects of different levels of uncertainty (Lieberman & Asaba, 2006).

We add to this work by showing that positioning imitation has similar effects on performance outcomes to action imitation, despite being independent of it, and by developing arguments regarding how the unpredictability of future environmental conditions (i.e., environmental uncertainty) can be leveraged in rivalry-based imitation. In particular, we contribute to the previous discussion on winner-take-all competition by showing how imitation and control of relative positioning can be the path to success in such conditions. Thereby, we shed some light on the critical gap in our understanding of the performance outcomes of imitation decisions (Semadeni & Anderson, 2010). Our findings support the view that imitation strategies can lead to good performance for leaders.

Finally, we contribute to the work that has pointed out environmental uncertainty and competition as a fruitful area of study (Bettis & Hitt, 1995; Ghemawat & Cassiman, 2007; Lieberman & Asaba, 2006). We argue that the combined effect of action imitation and positioning imitation reduces leader exposure to uncertainty and therefore lowers the likelihood of the leader losing his lead, and that this effect becomes stronger the larger is the leader's initial advantage and the greater is the degree of uncertainty in the environment.

The unexpected finding that environmental uncertainty in fact seems to negatively moderate the relationship between imitation and performance, though not significantly in most specifications, is worth discussing further. Prior literature and our arguments suggest that with increasing uncertainty an increase in the degree of imitation or a reduction in difference in positioning should more positively influence the likelihood of the leader staying ahead. Contrary to this, our results show the opposite effect. It is difficult to think of theoretical reasons supporting this unexpected result, and the moderating effects of uncertainty on imitation and difference in positioning should be examined in other empirical contexts in future work.

## **Limitations and further research**

While our setting is an ideal context in which to test our arguments using fine-grained data which allows us to create detailed measures of our constructs, the generalizability of our results to more commonly examined business contexts requires further exploration. Previous studies have highlighted the advantages and disadvantages of using laboratory-like sport contexts in order to advance theoretical understanding (e.g., Holcomb, Holmes, & Connelly, 2009), and future studies are necessary to empirically test our insights in company settings, using market share leadership as a dependent variable, for example.

Regarding the empirical setting, our study lacks leader fixed-effects (i.e., for each team). We compensate for this limitation by clustering the standard errors in our models by leader and by controlling for team prior performance and for the experience of the helmsman of the leading team, but there may be other team-based influences on performance that we are not able control for.

A common problem in imitation studies is disentangling imitation from shared reactions to an environmental shock (Lieberman & Asaba, 2006). We used a lagged correlation for our imitation measure in order to circumvent this problem to some extent. However, future work should make use of a more fine-grained approach.

Our context allowed us to study our research question in a specific competitive setting: winner-take-all competition. Winner-take-all competition may be less common than competition of other kinds (Cockburn & Henderson, 1994) but is a phenomenon of increasing importance (Frank & Cook, 2010: 45). The use of unpredictability and changes in environmental conditions to gain or maintain an advantage in competitive interaction could be further explored in other settings, such as competition in international markets or competition in markets with strong network effects. Complementing our novel insights with ideas from studies on information-based

imitation may also further our understanding of factors that distinguish between information- and rivalry-based theories of imitation (cf. Asaba & Lieberman, 2011). Finally, our research focuses only on one type of uncertainty, but firms are often challenged by different types of uncertainty. Future research should consider how different types of uncertainty influence both the decision to imitate and its performance consequences.

## **Conclusion**

Volatile environments challenge competitors to prevent performance losses and stay ahead of a rival. Throughout this paper, we have argued that ‘follow-the-follower’, a reversal of follow-the-leader strategy, is an effective means for a leader of staying ahead in uncertain environments. The findings of this study support our argument and suggest that unless the leader imitates the follower’s actions, the leadership is likely to be lost. Our research reveals two distinct but complementary imitation strategies which enable leaders to successfully defend their relative advantage. We look forward to future work that develops further insights on the importance of environmental contingencies in competitive interactions.

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Table 1: Summary statistics

<b>Variable</b>	<b>Obs</b>	<b>Mean</b>	<b>S. D.</b>	<b>Min</b>	<b>Max</b>
Leader wins	148	0.905	0.294	0	1
Action imitation	148	0.123	0.524	-0.945	0.978
Positioning imitation	148	0.162	0.162	-0.741	-0.000
Environmental uncertainty	148	0.001	0.001	0.000	0.013
Initial advantage	148	68.946	74.678	-20	609
Leader uncertainty exposure	148	0.148	0.144	0.000	0.626
Leader penalty	148	0.014	0.116	0	1
Same initial trajectory	148	0.358	0.481	0	1
Leader AC experience	148	0.845	0.364	0	1
Difference in seeding	148	0.391	2.664	-7	7
Leader performance to date	148	0.459	0.287	0	1
Follower performance to date	148	0.441	0.314	0	1
Last upwind of race	148	0.486	0.502	0	1
Race number	148	3.581	2.353	1	10
Event number	148	3.358	1.662	1	6

Table 2: Correlations

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
<b>1. Leader wins</b>	1														
<b>2. Action imitation</b>	0.283	1													
<b>3. Positioning imitation</b>	0.317	0.298	1												
<b>4. Environmental uncertainty</b>	0.057	-0.041	0.041	1											
<b>5. Initial advantage</b>	0.151	0.061	0.059	0.018	1										
<b>6. Leader uncertainty exposure</b>	-0.154	0.118	-0.399	-0.077	0.089	1									
<b>7. Leader penalty</b>	-0.162	-0.073	0.057	0.005	-0.053	-0.050	1								
<b>8. Same initial trajectory</b>	0.097	0.481	0.334	-0.083	-0.015	-0.037	0.157	1							
<b>9. Leader AC experience</b>	0.116	0.032	0.298	0.001	0.088	-0.262	0.050	0.126	1						
<b>10. Difference in seeding</b>	0.055	0.116	0.125	-0.222	0.104	-0.108	0.038	0.166	0.282	1					
<b>11. Leader performance to date</b>	0.110	0.049	0.238	-0.058	0.036	-0.144	-0.142	0.007	0.379	0.120	1				
<b>12. Follower performance to date</b>	-0.207	-0.184	-0.071	0.092	-0.035	-0.026	-0.078	-0.117	0.026	-0.211	0.155	1			
<b>13. Race number</b>	-0.018	0.204	0.080	-0.137	0.028	0.027	-0.129	0.043	0.170	0.276	0.234	0.091	1		
<b>14. Last upwind of race</b>	0.130	0.029	0.044	0.001	0.435	-0.037	-0.114	-0.163	0.007	-0.019	0.050	0.004	-0.016	1	
<b>15. Event number</b>	0.098	-0.094	-0.053	0.152	-0.281	-0.021	-0.025	-0.128	-0.031	-0.102	0.037	0.232	0.133	0.083	1

Table 3: Regression results

DV: Leader wins.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
<b>Leader uncertainty exposure</b>	-5.101* (2.23)	-7.529* (2.37)	-3.623 (1.24)	-6.085+ (1.67)	-5.558 (1.58)	-5.617 (1.56)	-5.526+ (1.85)	-6.535+ (1.75)	-4.605 (1.41)	-4.458 (1.28)
<b>Leader penalty</b>	-5.530+ (1.65)	-4.667* (2.10)	-5.277+ (1.77)	-4.968* (2.29)	-5.032* (2.32)	-5.305* (2.46)	-5.266* (2.25)	-4.886* (2.14)	-5.021* (2.18)	-5.728* (2.19)
<b>Same initial trajectory</b>	1.104 (0.78)	-1.106 (0.83)	0.570 (0.35)	-1.387 (0.98)	-1.661 (1.04)	-1.790 (1.02)	-1.713 (0.98)	-1.534 (0.94)	-2.638 (1.30)	-2.841 (1.01)
<b>Leader AC experience</b>	1.026 (1.34)	1.574* (2.07)	0.673 (0.81)	1.423+ (1.87)	1.308 (1.51)	1.270 (1.40)	1.444 (1.43)	1.459+ (1.67)	1.877* (2.02)	2.852* (2.36)
<b>Difference in seeding</b>	-0.064 (0.24)	-0.049 (0.13)	-0.064 (0.21)	-0.040 (0.10)	-0.029 (0.07)	-0.029 (0.07)	0.035 (0.09)	-0.022 (0.06)	-0.000 (0.00)	-0.001 (0.00)
<b>Leader performance to date</b>	1.229 (1.58)	0.714 (0.48)	0.607 (0.53)	0.213 (0.13)	0.383 (0.22)	0.177 (0.09)	0.739 (0.41)	0.680 (0.39)	-0.049 (0.03)	0.552 (0.22)
<b>Follower performance to date</b>	-4.374* (2.47)	-3.950** (2.91)	-3.791** (2.63)	-3.839** (2.97)	-3.656** (2.75)	-3.794** (2.87)	-3.915** (3.16)	-3.903** (2.85)	-4.044*** (4.04)	-5.310*** (4.89)
<b>Race number</b>	-0.247 (0.91)	-0.497+ (1.78)	-0.229 (0.81)	-0.539+ (1.80)	-0.616+ (1.94)	-0.614+ (1.92)	-0.764+ (1.93)	-0.667* (1.97)	-0.713+ (1.89)	-1.105* (2.28)
<b>Last upwind of race</b>	-0.516 (0.43)	-0.604 (0.39)	-0.330 (0.29)	-0.620 (0.42)	-0.719 (0.46)	-0.672 (0.42)	-0.774 (0.43)	-0.954 (0.61)	-0.170 (0.10)	-0.992 (0.45)
<b>Event number</b>	0.387+ (1.69)	0.664** (2.67)	0.463* (2.42)	0.756** (3.14)	0.846*** (3.69)	0.823*** (3.63)	1.013*** (3.36)	0.968*** (4.28)	0.799*** (3.41)	1.224* (2.10)
<b>Environmental uncertainty</b>	585.957 (0.83)	1,000.505 (1.11)	315.713 (0.55)	810.325 (0.89)	829.179 (0.95)	451.969 (0.51)	-974.045** (2.66)	1,060.326 (1.18)	530.487 (0.57)	-2,002.464 (1.12)
<b>Initial advantage</b>	0.020* (2.28)	0.019* (2.02)	0.018* (1.98)	0.018+ (1.91)	0.020* (2.00)	0.019+ (1.94)	0.023* (2.47)	0.027* (2.15)	0.055* (2.18)	0.120** (3.01)
<b>Action imitation</b>		3.435*** (4.13)		3.385*** (3.80)	4.709*** (3.66)	5.742* (2.48)	5.028** (3.08)	3.953* (2.49)	4.805** (3.01)	5.089+ (1.87)
<b>Positioning imitation</b>			4.044+ (1.94)	3.287* (2.04)	6.235* (2.37)	6.448* (2.36)	11.716*** (3.56)	6.755** (2.71)	2.766 (1.00)	11.497+ (1.79)
<b>Action imitation x positioning imitation</b>					7.012* (2.22)	7.383* (2.10)	7.789+ (1.68)	9.511*** (3.30)	4.927 (1.03)	14.003** (2.76)
<b>Action imitation x env. uncertainty</b>						-1,286.147 (0.83)				-638.037 (0.29)
<b>Positioning imitation x env. uncertainty</b>							-8,305.387* (1.99)			-9,609.605 (1.14)
<b>Action imitation x initial advantage</b>								0.035*** (4.19)		0.099* (2.37)
<b>Positioning imitation x initial advantage</b>									0.115+ (1.80)	0.212*** (4.55)
<b>Intercept</b>	2.640 (1.50)	3.345+ (1.75)	3.491 (1.60)	4.203+ (1.95)	4.635+ (1.94)	5.245+ (1.88)	5.792* (2.43)	4.184+ (1.82)	4.467 (1.55)	6.099* (2.22)
<b>Log pseudolikelihood</b>	-30.82	-25.00	-28.89	-24.20	-23.61	-23.48	-22.06	-22.68	-21.71	-18.18
<b>McFadden pseudo-R2</b>	0.33	0.46	0.38	0.48	0.49	0.49	0.52	0.51	0.53	0.61
<b>N</b>	148	148	148	148	148	148	148	148	148	148

+ p<0.1; \* p<0.05; \*\* p<0.01; \*\*\* p<0.001. Absolute values of t-statistics are in parentheses. All models are estimated using heteroscedasticity-robust standard errors clustered by leader identifier.

Figure 1: Race course, boundaries, and example trajectory of competitor B

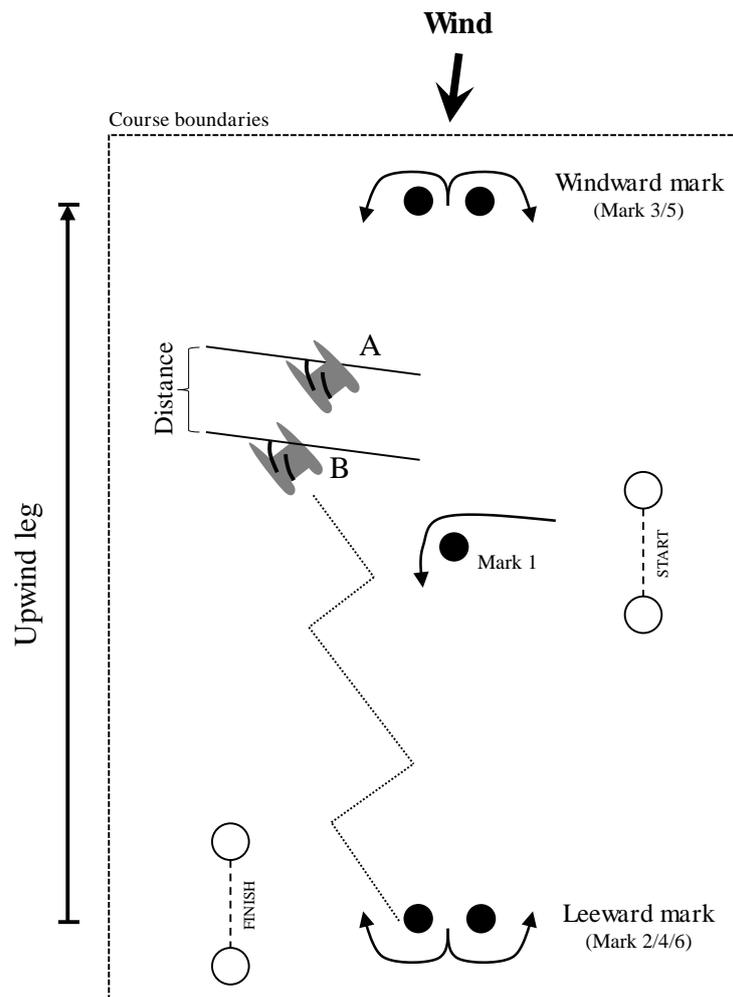


Figure 2: High action imitation and different levels of positioning imitation

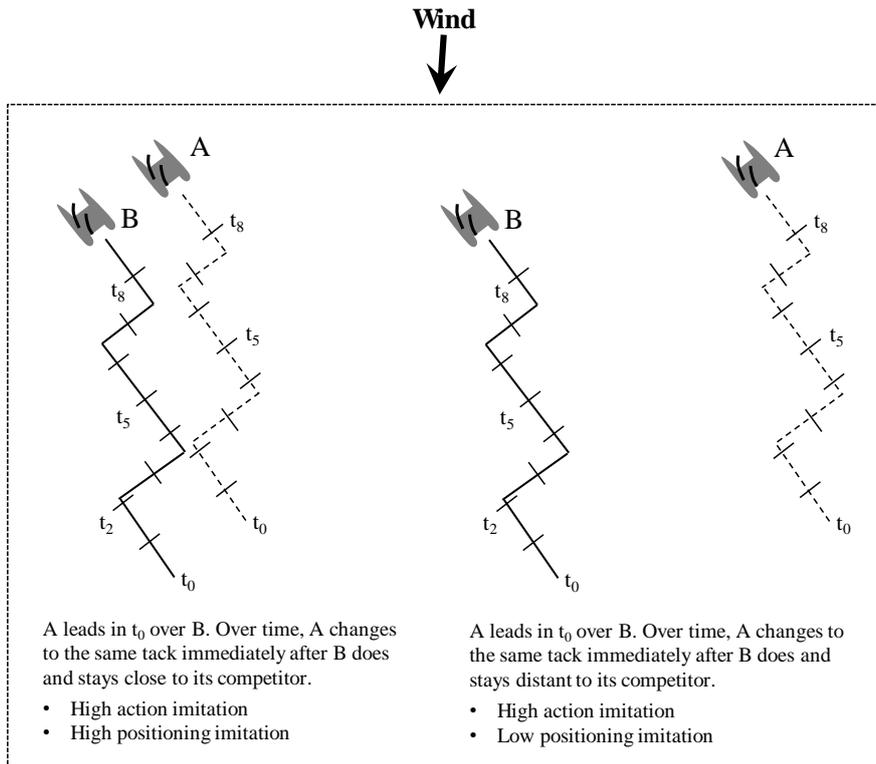


Figure 3: Low action imitation and different levels of positioning imitation

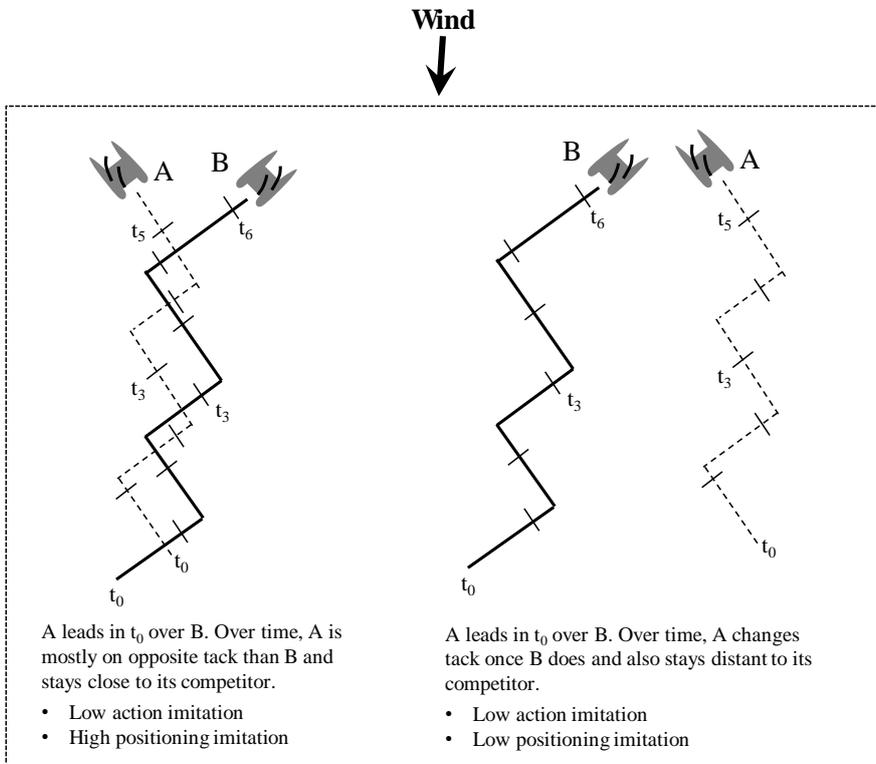


Figure 4: Plots of marginal effects on likelihood of the leader staying ahead

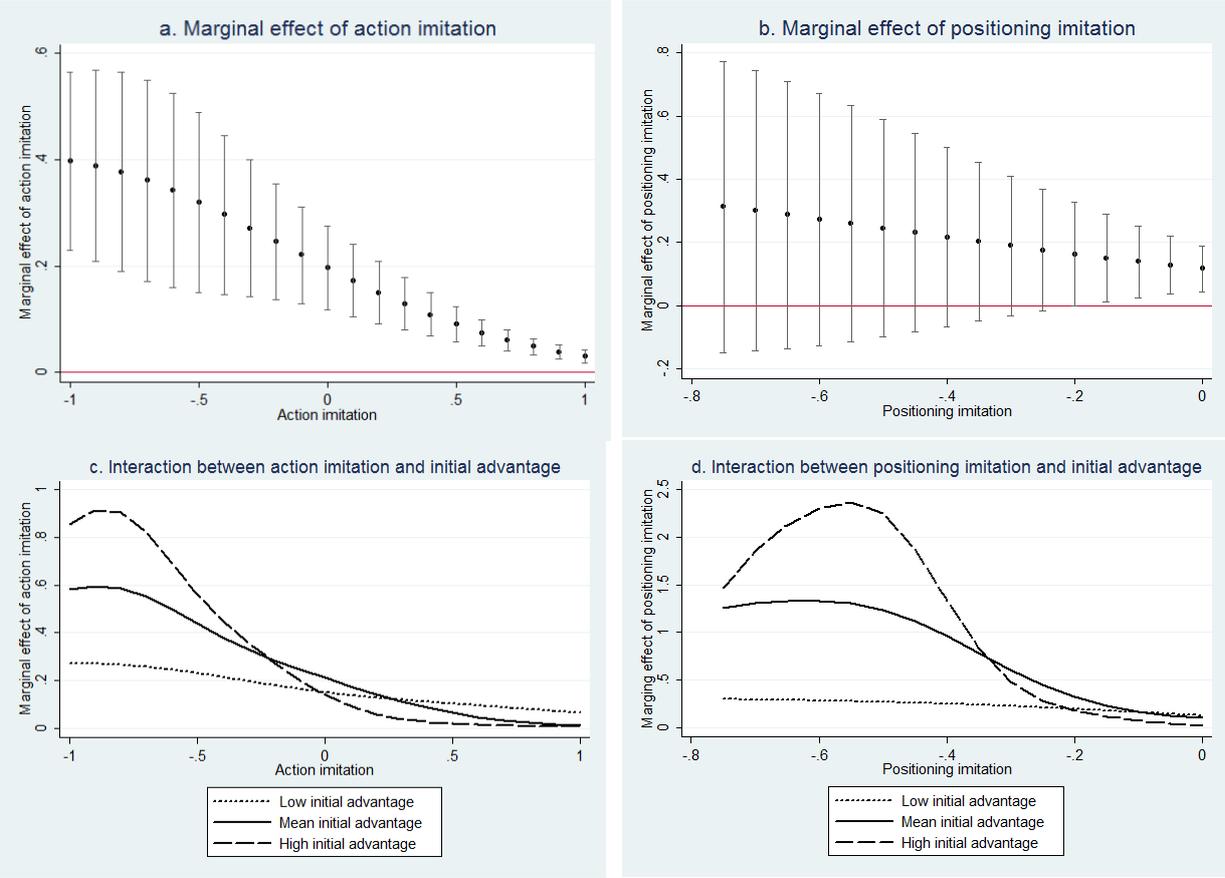


Figure 5: Interaction between imitation and difference in positioning

