Partial Imitation of Competitors due to Asymmetries in Internal Interdependencies:

Micro-level Evidence from Esports Tournaments

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Abstract

We investigate why even firms imitating the same competitor's strategy in the same environment often imitate different components of that strategy. We argue that these differences can arise because different firms vary in the internal interdependencies that underlie their strategies. When a firm significantly differs from a competitor in how one component interacts with other components of its strategy, it is less likely to imitate the competitor's decisions about that component because it is difficult to predict the overall consequences of the decision. We discuss how imitators' internal coordination mechanisms may help mitigate barriers to imitation arising from interdependence asymmetries, and test our resulting hypotheses in the context of esports where small teams of professional video-game players compete in high-stakes tournaments.

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Strategic imitation, which occurs when competitors attempt to reproduce each others' choices in pursuit of competitive advantage (Posen *et al.*, 2023), has been a central topic for research on strategy and organizations (Gaba and Terlaak, 2013; Gimeno *et al.*, 2005; Lieberman and Asaba, 2006). Much of this research reinforces the intuitive expectation that imitation reduces heterogeneity among competitors. However, scholars have recently begun to question the inevitability of such an outcome (Naumovska, Gaba, and Greve, 2021; Posen *et al.*, 2023; Posen and Martignoni, 2018). Imitation can also breed heterogeneity, they argue, because it is often *partial*: organizations may not imitate all components of their competitors' strategies but only a subset of them. The notion of partial imitation opens up the possibility that different imitators may differ in which objects they decide to imitate from a given competitor, so that they may end up with different bundles of capabilities even if they all imitate the same firm (Lewin, Massini, and Peeters, 2009; Posen, Yi, and Lee, 2020). This has the potential to be highly impactful in explaining competitive dynamics and making progress in understanding the origins of heterogeneity among competitors—a fundamental question for strategy research (Rumelt, Schendel, and Teece, 1994).

Prior work has highlighted that partial imitation may be a product of environmental factors, such as IP laws precluding imitation of some practices of a competitor and not others (Klevorick *et al.*, 1995). It may also arise because competitors take measures to protect or hide some of their practices (Sharapov and MacAulay, 2022; Sun *et al.*, 2010), or because some practices are more complex than others and thereby harder to replicate (Ethiraj, Levinthal, and Roy, 2008; Rivkin, 2001). However, even holding the environment and the target competitor fixed, we know that firms can still differ substantially in what they choose to imitate. For instance, the strategies and products of Apple and Southwest Airlines have been widely imitated by competitors in their respective industries, but different competitors differ substantially in which components they have replicated (Lindtner, Greenspan, and Li, 2015; Majerová and Jirásek, 2023; Wang *et al.*, 2023). The drivers of these differences are likely to lie within the imitating organizations themselves. Existing research offers us limited guidance in explaining these drivers, which is important because it can help us better understand the origins of interfirm heterogeneity in strategies.

This paper aims to help fill this gap by building and testing arguments rooted in the evolutionary perspective on organizational search (Csaszar and Siggelkow, 2010; Levinthal, 1997; Posen, Lee, and Yi, 2013; Rivkin, 2001). We conceptualize organizations as making choices about different strategy components with varying patterns of interdependence (Siggelkow, 2002; Simon, 1962). Interdependencies affect whether and how choices in relation to one component generate spillover effects for other components (Clement, 2023; Henderson and Clark, 1990; Levinthal, 1997). Because of this, scholars have suggested that the pattern of interdependencies between the components of an organization's strategy can affect whether competitors imitate it by shaping the causal ambiguity experienced by potential imitators (Csaszar and Siggelkow, 2010; Ethiraj *et al.*, 2008). We argue that these interdependencies also affect an organization's own tendency to imitate others and particularly *which* components of its competitors' strategies it tends to imitate. When an organization and its competitor differ in how a given component of their strategy interacts with others, the consequences of replicating the competitor's choices in relation to this component become less predictable for the imitator: the pattern of interdependence that made a component-related choice successful in one organization may not be present in the other, making it harder to gauge whether imitation will be effective (Csaszar and Siggelkow, 2010). As a result, we expect that an organization is more likely to imitate a competitor's choice about a strategic component if that component interacts with others in similar ways in the two organizations.

Our theory helps explain why organizations may imitate some components of a competitor's strategy but not others, and why organizations may differ systematically in which components they imitate. Importantly, in contrast to prior mechanisms explaining partial imitation, our theory can explain these differences even when competitors are able to perfectly observe each other's choices and the interdependencies among them. Because the mechanism underlying our theory is that some organizations face more uncertainty than others in predicting the consequences of imitating strategy components, we suggest that another factor affecting their imitative behavior is whether they can rely on coordination mechanisms that help them alleviate this uncertainty. We consider how this coordination may be achieved explicitly through communication between decision-makers responsible for different components, or more implicitly via shared mental representations developed through collaborative experience (Hansen, 1999; Srikanth and Puranam, 2011; Thompson, 1967).

We test these ideas empirically in the context of esports, an industry in which small teams of professional video-game players compete for substantial prizes. Our data are drawn from major tournaments of the popular esport game DOTA 2 (Ching, Forti, and Rawley, 2021; Clement, 2023). The setting enables us to alleviate two major empirical impediments faced in earlier research. First, it is often difficult to observe internal processes with sufficient granularity in a large sample of organizations to infer differences between competitors in the component-level choices they make and in the pattern of interdependencies between components. In our setting, we can rely on detailed digital traces of teams' behavior to (1) observe how they choose between different "heroes" to fulfill different roles corresponding to components of their team's activity, (2) measure the pattern of interdependencies between these different roles in each team and (3) measure the coordination mechanisms each team can rely on. Second, exposure to other organizations' choices is affected by self-selection in most settings: organizations can choose the other organizations whose choices they are exposed to, for example by choosing specific market segments to compete in or entering partnerships with other organizations. This self-selection makes it difficult to distinguish the drivers of imitation from the drivers of exposure (de Vaan and Stuart, 2019). In DOTA 2, exposure occurs primarily via direct matchups, as teams have the greatest visibility over the choices of other teams they directly confront. In the tournaments we study, matchups are effectively randomized, making exposure exogenous to imitation. We leverage this aspect of our data to estimate how the patterns of interdependencies within teams differentially impact imitation across different activities.

Supporting our theory, we find that a team is substantially more likely to imitate the hero used by recent opponents in a specific role if the pattern of interdependence between that role and other roles is more similar between the focal team and its recent opponents. As these patterns of interdependence diverge, imitation becomes less likely except if the player in that role has significant collaborative experience with their teammates or communicates extensively with them, providing them with a better ability to resolve this uncertainty. Overall, these findings suggest that the internal structure of an organization can have significant and heterogeneous effects on its propensity to imitate its competitors' choices about *some* strategy components but not others.

THEORY

Historically, imitation has been cast in both popular and academic writing as the opposite of innovation (Mansfield, 1961). Early work in industrial organization (IO) economics considered how inferior firms might survive in a market by imitating its leader, while follow-on work contemplated how barriers to imitation may allow leaders to preserve their advantage and reduce the ability of firms to move from one strategic group to another (Lippman and Rumelt, 1982; Schmalensee, 1985). Common to these works—as well as more contemporary studies (Cui, Calantone, and Griffith, 2011; Pacheco-de-Almeida and Zemsky, 2007) is the view of imitation as a binary choice: either a firm replicates a strategy, practice, or technology entirely, or it does not imitate it at all.

While this perspective has led to important advances in our understanding of competitive dynamics among firms, strategy scholars have also pointed out that it may limit our ability to understand how imitation relates to heterogeneity among competitors (Posen *et al.*, 2013): when imitation is treated as a binary choice by a firm to resemble its competitor, it is inevitably seen as reducing heterogeneity within a population. This intuition may not hold once we engage more fully with the reality that imitation is multidimensional: organizations' activities and strategies are made up of various distinct elements, so that competitors may selectively replicate some elements of each other's strategy and not others (Csaszar and Siggelkow, 2010; Posen *et al.*, 2023; Rivkin, 2001). As a result, an organization may combine some components of its competitors' strategies with its own capabilities, leading to novel combinations. This is a critical distinction because it opens up the possibility that imitation may facilitate recombination rather than eliminate variation, and in fact increase heterogeneity among competitors (Posen and Martignoni, 2018).

Given the meaningful implications of partial imitation, scholars have tried to investigate when and why it happens. Much of the existing research on the topic has come from computational work in the Carnegie tradition, which has typically modeled imitation as a firm replacing a subset of its components with those of a rival (Levinthal, 1997). This research has yielded substantial insight into imitation deterrence, arguing for instance that the structure of interdependencies between the different elements of a firm's strategy can systematically influence its likelihood of being imitated (e.g., Ethiraj *et al.*, 2008; Rivkin, 2001). This research has also considered how such complexity can impact the breadth of imitation, i.e., how many of the strategy's components are imitated (e.g., Csaszar and Siggelkow, 2010). It has also considered the possibility of imperfect imitation, errors made in imitating a particular strategy leading to an accurate replication of some of its components and not others (e.g., Posen *et al.*, 2020).

Research has also highlighted that partial imitation may arise from limits to the visibility of some elements of the target technology. For instance, the early power looms used by the Boston Manufacturing Company to establish the textile industry in the United States were partial imitations of those in England. Restrictions on the export of this technology meant that the knowledge of only some of its components that could be gained via observation could be imitated, and the remainder had to be improvised (Morris, 2012; Posen and Martignoni, 2018; Rosenberg, 2010). Similarly, the imitation of some elements of a strategy may be precluded by laws such as intellectual property protections, leaving only the remainder open to imitation (Klevorick *et al.*, 1995; Pisano, 2006). Alternatively, some components of a firm's strategy may be costly to imitate due to efforts taken by this firm to hide them, i.e., secrecy (Alcacer and Zhao, 2012), or because of the tacitness of the knowledge underlying these components (Autio, Sapienza, and Almeida, 2000). In sum, this literature has highlighted a range of important antecedents to partial imitation that relate to characteristics of the environment and of the target of imitation.

While these are important factors, evidence suggests that they paint an incomplete picture. Namely, even firms imitating the same competitor's strategy in the same environment often imitate different components of that strategy. Consider the widely discussed strategy pioneered by Southwest Airlines in low-cost aviation. This strategy was enabled by specific practices in relation to a range of different components including the use of a homogeneous fleet, point-to-point services, widespread use of secondary airports, direct marketing, payment for frills etc. (Kim and Mauborgne, 2002; Porter, 1996). Southwest became the target of substantial imitation within its industry. However, different competitors differed significantly in which of Southwest's practices they replicated, with a range of models emerging that drew on different elements of Southwest's approach (Majerová and Jirásek, 2023). Note that many of the drivers of variation in partial imitation highlighted in prior research are unlikely to apply here given Southwest's practices were highly visible and not protected by IP restrictions. Of course, some of this variation could relate to differences in imitators' interpretations of how the strategy drives performance. However, as we will argue, some of it is likely to relate to how imitators' own strategy components are organized internally. Existing research on imitation offers us limited guidance in explaining differences arising via this channel, which is a meaningful gap given its implications for the emergence and persistence of heterogeneity between competitors.

Strategic imitation is ultimately aimed at the pursuit of competitive advantage (Lippman and Rumelt, 1982). However, the specific pathway towards competitive advantage that imitation facilitates can vary. For instance, imitation may be aimed in the short term at reversing a performance decline, bridging gaps in performance to specific competitors, responding to a technology-driven change, exploration of a new business model, or attaining legitimacy in the eyes of a specific audience. (Ordanini, Rubera, and DeFillippi, 2008; Posen *et al.*, 2023). As in the prior work that we build on, we do not distinguish between these immediate motivators of strategic imitation (Csaszar and Siggelkow, 2010; Rivkin, 2001). We anticipate a baseline propensity to engage in imitation that operates within a population of firms, and consider how that baseline moves on average corresponding to the specific factors we are interested in. Specifically, our theory predicts that an asymmetry in interdependencies will, on average, act as a drag on the propensity to imitate regardless of the immediate objective animating that desire to imitate.

Mismatch in Interdependencies and Component-level Imitation

In addressing our question of interest, we adopt a conceptualization similar to the one used in the computational work that made prior progress in understanding partial imitation: the components that make up an organization's strategy refer to the choices or decisions made in relation to its different activities (Csaszar and Siggelkow, 2010; Ethiraj *et al.*, 2008; Posen *et al.*, 2013; Rivkin, 2001). Two components are interdependent when the value of choices made about one varies depending on choices made about the other (Levinthal, 1997; Raveendran, Silvestri, and Gulati, 2020; Thompson, 1967). These interdependencies can arise from a variety of factors such as consumer preferences for coherent sets of component choices, or historical organizational endowments such as routines that generate value across specific combinations of components, or distinctive resources which are used simultaneously to deploy several components. The extent and nature of interdependencies between components can vary substantially both within and across organizations (Gokpinar, Hopp, and Iravani, 2010; Sosa, Gargiulo, and Rowles, 2015). Within an organization, some sets of components may be highly interdependent with each other while others are largely independent. Across organizations, the same pair of components may be highly interdependent in one organization while functioning relatively independently in another (Simon, 1962). For instance, the product design activities of one smartphone company may be closely intertwined with its engineering activities, while in another they may be less intertwined with engineering but more closely intertwined with marketing activities. Figure 1 summarizes our conceptualization, which closely resembles the one featured in NK models of search where actors make choices about different components with varying patterns of interdependence. In the figure, organization A and its competitors B and C each make choices relevant to five strategy components (with each choice taking a value of -1, 0, or 1). The figure shows the interdependencies of components 1 and 2 with the other components in each of the three organizations. These patterns can be similar or different between competitors. For example, the pattern of interdependencies $Int[d_{A,1}]$ surrounding component 1 in organization A is similar to the corresponding pattern $Int[d_{B,1}]$ in competitor B but not the pattern $Int[d_{C,1}]$ in competitor C. The reverse is true for the pattern of interdependencies $Int[d_{A,2}]$ surrounding component 2 in organization A.

INSERT FIGURE 1 HERE

While existing research has suggested that interdependencies between the components of an organization's strategy can shield it, in aggregate, from being imitated by competitors (e.g., Rivkin, 2001), it has not considered how these interdependencies affect the organization's own propensity to imitate competitors. This is surprising given that prior work has shown that interdependence structures within organizations influence their strategic choices by shaping their ability to predict the impact of these choices (e.g., Aggarwal and Wu, 2015; Clement, 2023). The impact of choices about strategy components depends not only on the effectiveness of these choices in isolation—for instance, how effectively a practice would accomplish its intended function under ideal conditions—but also on the degree to which they fit the specific organizational environment within which they are made. This fit depends in part on the spillover effects which a choice about one component may generate for other components that depend on it (Henderson and Clark, 1990; Levinthal, 1997). Foreseeing such spillovers is a difficult endeavor: a broad literature underscores how difficult it is to predict the impact of an organization's choices in the face of interdependencies between decisions (Clement, 2023; Eggers and Kaplan, 2009; Martignoni, Menon, and Siggelkow, 2016). Firms are more likely to make decisions when they face less uncertainty in assessing the decisions' impact or when they possess the ability to resolve this uncertainty (Camerer and Weber, 1992; Samuelson and Zeckhauser, 1988).

The arguments above suggest that the patterns of interdependencies within which a component is embedded may be an important factor affecting the imitation of choices relating to it. Specifically, we argue that an organization is more likely to imitate a competitor's choice about a component if the component interacts with others in similar ways at the two organizations. This similarity helps decision-makers predict the impact of a choice not by relying fully on rational deduction (i.e., computing "from scratch" the choice's likely impact on other components) but by relying on analogical reasoning: the likelihood of the practice performing similarly in both organizations increases if the pattern of interdependence in which the relevant activities are embedded within both organizations are more similar (Gavetti, Levinthal, and Rivkin, 2005;

Szulanski, 1996). Better predictability, in turn, makes decision-makers more likely to implement a new choice (Camerer and Weber, 1992; Samuelson and Zeckhauser, 1988)[1].

Hypothesis 1: An organization is more likely to imitate a competitor's choice about a strategic component if the pattern of interdependence between this component and others is similar in the two organizations.

Our arguments so far suggest that the imitation of choices relevant to a strategic component may be limited by the level of similarity between competitors in the interdependence structures within which that component is embedded. As summarized in Figure 1, this suggests that the focal organization is more likely to imitate a choice about component 1 from competitor B than competitor C (because component 1 interacts with other components more similarly in these two organizations), but the reverse is true for component 2 (for which interdependence patterns are more similar in competitor C). Dissimilarity, or mismatch, generates uncertainty in predicting the impact of imitation in the target organization and thereby makes it less likely.

If this uncertainty is the factor limiting imitation in the face of such mismatch, mechanisms which allow an organization to resolve uncertainty should be especially potent in promoting imitation when there is mismatch in interdependencies between an organization and its competitor. We focus on the role of organizational coordination mechanisms. Coordination mechanisms are likely to be relevant because, in most organizations, strategic decisions are influenced by several

[1] In practice, the mechanisms we describe here are filtered through the prism of the decision makers' perceptions of similarity. In other words, an organization is more likely to engage in imitation in relation to a component if its decision makers *perceive* that component to be embedded in similar patterns of interdependencies in both organizations. These perceptions may be a product of direct observation, information gained via industry networks or reputations built up over a period of time. For theoretical clarity with regards to the key mechanisms we are focusing on in this study, our arguments make the assumption that perception equals reality, which is the case in our empirical setting since there is complete visibility into the internal structures of competitors. We expect the mechanisms to operate similarly in guiding imitation even if the perceptions are inaccurate, i.e., while the consequences of such imitation may vary based on the accuracy of these perceptions, we expect the initial choice of whether and what to imitate, which is the focus of our attention here, to be largely unaffected by whether the perceptions are accurate or not. We describe this assumption and its implications in more detail in the discussion section.

decision-makers who hold specialized knowledge about different strategic components (Cyert and March, 1963). Interdependent specialists can often struggle to understand the collective consequences of new choices (Clement, 2023; Lounamaa and March, 1987; Puranam and Swamy, 2016). Interdependence mismatch with a competitor makes predicting the consequences of adoption more difficult, both for the focal component and others that have interdependencies with it. As a result, an organization is unlikely to imitate a component choice made by a mismatched competitor unless decision-makers can rely on mechanisms that reinforce their confidence that they can successfully implement the same choice—either by helping them collectively reduce uncertainty about its impact or by enhancing confidence in their ability to collectively adapt to the consequences of adoption despite this uncertainty (Cyert and March, 1963; Galbraith, 1973). Below, we consider how such mechanisms may derive from decision-makers' coordination capabilities, which may be developed actively through communication between them or passively through the development of shared experience over time (Srikanth and Puranam, 2011).

A considerable body of evidence attests to the notion that "communication with one's contacts helps to resolve the uncertainty surrounding the value of an innovation" (Davis, 1991: 593). Within an organization, effective communication allows decision-makers to resolve uncertainty about how a choice made about one part of the organization may impact other parts and, consequently, the outcomes for the organization in aggregate (Garicano and Wu, 2012; Van de Ven, Delbecq, and Koenig Jr, 1976). It also allows different decision-makers to engage in mutual adjustments as they seek to adapt their behavior to fit newly adopted practices. This fits what Thompson (1967) describes as coordination by mutual adjustment achieved through the transmission of information. The existence of established patterns of communication should reinforce decision-makers' confidence that the different parts of the organization can adapt as necessary to localized changes.

Overall, these arguments suggest that communication among decision-makers should allow them to collectively reduce uncertainty about the impact of adopting new practices locally and to feel confident in their ability to adapt through mutual adjustment even if some uncertainty remains. This leads to the following prediction:

Hypothesis 2: When the pattern of interdependence between a strategic component and others is dissimilar in an organization and its competitor, the organization is more likely to imitate the competitor's choice about this component if there is more frequent communication between its decision-makers.

As an alternative to explicit communication, decision-makers can also resolve uncertainty by relying on a tacit understanding of the interdependencies between the components they specialize in. We focus on prior collaborative experience between decision-makers as a way of generating such understanding.

Familiarity between decision-makers developed as a result of repeated collaboration facilitates a better understanding of how different decision areas relate to each other and of how decisions in one area impact others (Edmondson *et al.*, 2003; Nelson and Winter, 1982). Relatedly, organizational research has extensively documented the "disambiguating quality of strong ties" (Strang and Still, 2006). For instance, Hansen (1999) found that strong inter-unit ties within an organization are especially beneficial for decision-making in projects involving more complex, less codifiable forms of knowledge. These relationships facilitated the development of a shared understanding—a "relationship-specific heuristic" that enabled more effective engagement between individuals from the different units (Hansen, 1999: 88). Mizruchi and Stearns (2001) demonstrate a similar relationship in the context of a bank, where managers are better equipped to close deals of high uncertainty with their corporate clients when they have strong ties with their peers. These relationships enable bankers to vet deals in advance more effectively, thus enabling them to identify courses of action that would meet with the approval of their organization.

Hence, we expect collaborative experience between decision-makers to affect the imitation of component-level choices in the same way as explicit communication: a shared understanding developed through repeated collaboration may help decision-makers both to reduce uncertainty about the impact of adopting new practices locally and to feel confident in their ability to adapt through mutual adjustment even if some ambiguity remains. Hence, we predict:

Hypothesis 3: When the pattern of interdependence between a strategic component and others is dissimilar in an organization and its competitor, the organization is more likely to imitate the competitor's choice about this component if its decision makers have more collaborative experience.

DATA AND METHODS

Testing our arguments required us to find organizational data with sufficient granularity to observe choices made about different strategy components within an organization, measure the interdependencies between these components, and observe coordination among decision-makers—all of this over a comprehensive enough set of organizations to predict variation in their imitative behavior. To fit these requirements, we set our empirical investigation in esports, also known as competitive video-gaming. In esports, professional teams compete in video game tournaments with substantial cash prizes, frequently over $1 million. These matches are watched by thousands of viewers in stadiums and millions over the internet[2]. In recent years, this industry has also received increased interest from artificial intelligence researchers (e.g. McCandlish et al., 2018) and organizational scholars (Ching *et al.*, 2021; Clement, 2023).

[2] https://www.statista.com/statistics/490522/global-esports-market-revenue/

Decisions and coordination in DOTA 2

For this study, we focus our attention on one specific esport: "Defense of the Ancients 2" (DOTA 2). DOTA 2 is among the games with the most developed esports infrastructure in terms of players, viewers, and prize pools; it also generates very comprehensive data on team dynamics.[3] Any game of DOTA 2 involves a match between two teams of five players each. Each team collectively selects one "hero" for each of their players, which is a character that the player will control for the duration of the game. There are over a hundred possible heroes to choose from, each with a specific combination of abilities. Once heroes have been chosen, teams engage in a battle which concludes when one team has destroyed the other's main building, called the "Ancient."

Gameplay, especially at the professional level, has evolved into a highly strategic contest that industry insiders describe as a mix of basketball and chess. The range of strengths of the different heroes, and the multitude of ways in which they can be deployed collectively, has generated substantial complexity and variation in the approaches employed by teams. The stability of membership in esports teams is broadly comparable to professional sports like football. While there are movements across teams, and new players enter the dataset over time as teams seek new talent, players typically remain with a team for considerable periods of time (only around 15% of the players in our data play for more than one team during the sample period). Players also have high-powered incentives to perform well as a collective, as they collectively earn the large majority of their team's earnings in tournaments.[4]

Most importantly with respect to our study, DOTA 2 teams feature a division of labor which, like in many traditional organizations, involves the decomposition of a team's activity into bundles of tasks fulfilled by different members. The different bundles of tasks in DOTA 2 are stable enough

[3] https://www.bloomberg.com/news/newsletters/2021-08-27/world-s-most-lucrative-esports-event-dota-2-returns-to-live-play

[4] The highest-earning team in 2021 earned over 18 million US dollars.

across teams that they have been institutionalized as five recognizable roles with specific names[5]. This setup allows for a good match with our theory because the strategies chosen by teams can be decomposed into choices about different strategy components relating to each role. Teams can choose between different collective strategies: for instance, a team may opt for an aggressive strategy seeking to rapidly destroy the opponent's buildings, or it may opt for a more defensive style by waiting for the opponent's attack before counterattacking. While a team may adapt its approach from game to game to counter specific opponents, professional teams (as in conventional sports) develop specific styles of play honed over long periods which define their core strategy. These styles remain relatively stable across games and tournaments. In turn, any given strategy is instantiated through a set of choices about each role. By far the most consequential choice made by a team about each role is the selection of a hero for that role. A team's decision to select a specific hero for a role is based on how that hero's abilities allow it to embody a component of its team's strategy. For instance, a team playing with an aggressive strategy will tend to choose a hero for its "safe-lane carry" role whose abilities allow it to engage in fights early in a game while a more defensive team will tend to select heroes that start out weak but become much stronger towards the end of a game (often called "hard carry" heroes in DOTA 2 jargon).

The decision to choose specific heroes is made by a team before each game starts. This choice is typically made via a collective process: each player tends to have more decision power over the hero which they will use to fulfill their own role, but players in other roles also share their

[5] The "safe-lane carry" (also referred to as "position 1") role entails gathering resources without engaging in fights for the early parts of the game, and dealing the most damage during fights at the end of the game. The "mid-laner" role (or "mid-lane carry," position 2) involves gathering contested resources during the early part of the game and dealing the most damage during fights in the early and mid-game. The "off-laner" (or "off-lane carry," position 3) seeks to bear the brunt of the opponents' attacks and defend buildings, as well as initiating fights with the opponent. The "soft support" (position 4) is a more flexible role which may entail gathering uncontested resources (in the "jungle"), leading early attacks against the opponent's heroes and buildings, or defending against the opponent's attacks. The "hard support" (position 5) is mainly responsible for protecting the safe lane carry in the early stages of the game and providing support to the entire team during fights later in the game. Role allocations tend to be stable: some players specialize in the "safe-lane carry" role, others in the "hard support" role, etc.

opinions about which hero should be selected for this role based on how they expect this choice to fit the team's strategy. We were able to observe video recordings of teams during some high-stakes games which provide examples of this process, including the possibility of veto from other team members about a hero choice.

<u>Conversation recorded in 2017, during a game with $500,000 at stake</u>

Player 1 (for whom a hero is being picked): "*I'm considering between Dazzle and Crystal Maiden. What do you guys think?"*
Player 2: *"Well, I like the Dazzle against Legion Commander; I like the Crystal Maiden for the lanes."*
Player 1: *"Or Enigma for team fight."*
Player 3 (whose hero had already been chosen): *"No, I don't like it."*
Player 2*: "No, not if you want to do the lane thing."*
Player 4: *"I thought Dazzle was pretty legit."*
Player 1: *"Alright, let's go Dazzle."*

Empirical Design and Variables

A critical challenge to studying the antecedents of imitation empirically is that potential imitators typically self-select into which competitors they are exposed to. These choices are made purposefully, making it hard to empirically distinguish the drivers of imitation from the drivers of exposure (de Vaan and Stuart, 2019). For instance, we may observe that a company imitates others that are geographically proximate to it. However, our ability to discern a causal relationship between geographic proximity and imitation is limited by the fact that those companies may have chosen to collocate precisely to learn from each other.

Our setting of professional DOTA tournaments offers us a significant advantage in this respect. The average tournament in our data consists of a total of 217 matches, with each match typically lasting under 45 minutes. This high volume of matches makes it challenging for players to keep forensic track of events occurring in matches that their team isn't directly involved in. As a result, the most significant source of exposure in this setting comes from direct matchups: teams have the greatest ability to observe the actions of the opponents they play against. For each of the five players responsible for different roles in a DOTA 2 team, we measure imitation as the propensity to select heroes which were chosen by players fulfilling the same role in teams recently faced by the focal player's team, i.e., their most recent opponents. In the tournaments that are the source of our data, teams have no direct control over whom they face or in what order. Teams are initially randomly assigned into groups, within which each team plays every other team in a "round-robin" phase. Subsequently, a proportion of the teams in each group is eliminated, and the remainder go into a knock-out tournament where they compete against teams from the other group. Teams thus have little control over whom they play against, since this depends on the randomized assignment into groups and the results of other teams' matches[6]. As a result, the identity of opponents is effectively randomized. We then examine the consequences of this exposure in terms of a team's propensity to imitate its prior opponents' hero choices.

Another advantage of DOTA 2 is the granularity with which we are able to measure decisions and coordination within teams. Our raw data consist of every mouse-click and keystroke made by 10,266 players from 2,509 teams, for 13,874 matches played across 64 tournaments over a 3-year period (2014-2017). We obtained this data directly from files generated by Valve Corporation containing information about every input made by a player during a match. We turned this raw input into a dataset at the role-hero-game level: for each game played by each team during the study period, our dataset includes one observation for every possible hero available to fulfill each role (out of over a hundred available heroes). We use this dataset to predict whether a specific hero was chosen to fulfill a specific role. This granularity also allows us to make use of the breadth of information available about heroes, games, players, and teams—perhaps most notably in measuring the patterns of interdependencies between roles within teams, as we describe below.

[6] Results are also robust to only using data from the "round-robin" phase of tournaments where matchups are perfectly randomized.

Measuring imitation

All of our hypotheses relate to a team's likelihood of imitating its competitors' choices about different strategy components—i.e., hero choices in DOTA 2. Imitation, however, is not a straightforward concept to capture in a single variable: because imitation implies copying competitors' choices, measuring imitation requires (1) measuring both the focal organization's choices and those of its competitors and (2) isolating the latter's influence on the former net of other influences. To do so, we set up our regressions as predicting the focal organization's choice of a hero for each role during a game, using its recent opponents' hero choices for that role as a predictor (as well as control variables capturing additional influences as described below). Our regressions estimate the degree to which, all else being equal, a team's choice of hero for a role is sensitive to its recent opponents' choices of heroes for that role. We then consider how this sensitivity is moderated by the organizational factors we are interested in.

Given this specification, our dependent variable, $\textit{Hero Chosen}_{ithg}$, is defined at the hero-role-game level. It is a binary variable that is equal to 1 if team t chose hero h to fulfill role i in game g, and 0 otherwise. Given that each team includes five players who each fulfill one role in any game (e.g., "safe-lane carry," "hard support," etc.), this variable is predicted separately for five roles in each game. Our analysis then captures imitation by examining the degree to which a team's choice of a hero to fulfill a role is affected by recent opponents' use of this hero for the same role. $\textit{Prior opponents' use of hero}_{ithg}$ is measured as the fraction of team t's previous 20 opponents who picked hero h for role i in game g. Additional analyses reported below test the robustness of our results to alternative windows of 10 or 30 games instead of 20. Computing this variable required us to identify the role fulfilled by each player of a team in each game. To do so, we used a classification scheme provided by *dotabuff.com*, the main provider of statistics for DOTA 2. For each game, this website classifies players into roles by relying on the fact that, while each role can be fulfilled in different ways by different players, each role has stable tendencies in terms of starting position on the map (e.g., “safe-lane carries” and “hard supports” start the game in the “safe lane” located on a specific side of the map) and resource-gathering patterns (within a given lane, the “carry” gathers more resources than the “support”)[7]. These statistics are widely regarded as accurate and are frequently used by professional commentators and pundits.

Independent variables testing our predictions

Given the way in which we capture component-level imitation, all of the independent variables testing our hypotheses of interest are set up as moderators of the relationship between *Prior opponents' use of hero*$_{ithg}$ and *Hero Chosen*$_{ithg}$. These variables are operationalized as follows.

Interdependence Difference$_{ithg}$ – All players of a team are interdependent to a degree, but there can be significant variation in the extent of interdependence among players both across and within teams. Games are played within the boundaries of a map that does not change over time. Teams may choose to have separate subgroups of two, three, or four players operate in proximity to each other and work collectively on tasks such as gathering resources or executing attacks, and they may leave other players largely spread out over the map to focus on deploying their individual strengths. While there is variance from game to game, stable patterns emerge over time in the way teams operate, giving us meaningful variation in the degree of interdependence that characterizes different roles within a particular team. This variation exists because (1) some roles involve more interdependence and hence more need for coordination with other roles, and (2) even two teams that carry out similar strategies may vary in the extent to which two roles are interdependent. For instance, one team may implement an aggressive strategy by having all five players fight as a team in one region of the map while another team may implement a similar strategy by having separate groups of players attack the opponents in separate regions.

[7] This is analogous to positions in conventional sports, such as left midfield or center forward in soccer.

We measure a player's level of interdependence with their teammates based on the degree to which they participate in sequences of coordinated actions involving multiple teammates. First, based on the raw data on each player's actions during each game, we identify coordinated behavior as sequences of actions involving several of a team's players, in which each action was performed 3 seconds or less after the previous one, and within close geographical proximity (on the game map) to the previous action. Choosing this time frame reflects the fact that, in the game, collective behaviors unfold rapidly through collaboration among players in specific regions of the map. Two or more players who are in close proximity on the map and carry out actions in concurrence with each other are engaging in coordinated action. For instance, one player may use a hero's "disabling" ability to hold off or constrain opponents while others carry out an attack or some other critical activity in the same region. We capture all such sequences that the team engaged in during the 20 games preceding the focal game *g* to avoid simultaneity bias; hence, our measures capture a team's recent patterns of interdependence among its players[8].

Our interest for the purposes of hypothesis 1 is in comparing the pattern of interdependencies linking the focal role to other roles between the focal team and its competitor (i.e. a recent opponent). To capture this, we first characterize each role's level of interdependence with others as a vector with 4 dimensions, each indicating their degree of interdependence with each of the other roles in their team. Each dimension characterizes the percentage of coordinated actions which the player fulfilling that role is involved in that also includes the player fulfilling the other role. For instance, for a game in which the focal player fulfills role 1 ("safelane-carry") and engages in a total of 100 collective sequences of action, we may observe that 50 of these sequences also involve the player in role 2, 25 involve role 3, 40 involve role 4, and 80 involve role 5. The interdependence vector for

[8] These measures show substantially greater variance across teams than within teams over time, indicating that patterns of interdependence remain relatively stable within teams from game to game.

this game would then be [.50, .25, .40, .80]. We obtain this vector for each player of the focal team. We also obtain the equivalent vector for each player in each of the opponent teams' based specifically on the game the focal team played against that opponent, i.e., the game where the focal team observed that opponent most closely. We then calculate the average Euclidean distance between the vectors representing the focal role and the equivalent role on each of these prior opponent teams to obtain our measure of *interdependence difference*$_{ithg}$. This measure therefore captures differences in the stable patterns of interdependence that characterize the focal player, and the patterns that characterize role-equivalent players in the opponents' teams. While this vector distance is our primary measure, our results are also robust to using a more basic scalar operationalization of differences in the level (rather than pattern) of interdependence of the focal player with their teammates vs their counterparts. The robustness section below provides more detail on this alternative measure.

Communication$_{thg}$ – We capture the extent of communication between team members based on the number of "pings" per minute used by a team's players during a match. Pings are graphics-and-sound signals used during the game by players in order to clarify their meaning when they communicate. Players can generate a ping by clicking on the game map to show other players where they want some behavior to take place on the map. For instance, they may show a ping on the location where they want to ambush opponents. This measure captures an important means of communication for teams, and is likely to be correlated with the amount of vocal communication during a game, as explained by one of the professional players we interviewed: "*We communicate a huge amount with pings, so much that we don't even realize it anymore. It's almost part of the sentence. We use pings a lot because it's very easy: we just have to use our mouse and it makes a sound. With experience, your brain starts to really pay attention to it: I can hear a hundred different* *sounds in the game, but if I hear a ping, I know it's important*." We capture communication as the average number of pings per minute by the team's members during its past 20 games.

We capture this measure at the team level rather than at the player/role level for both conceptual and empirical reasons. Conceptually, we are interested in communication to the extent that it enables the transmission of information within the team. In this regard, the information the focal player has access to depends not just on their direct exchanges with the other players, but also on those other players' exchanges with each other. Empirically, since pings are a one-way signal, we cannot capture dyadic communication, only the number of signals sent out by each player. The number of pings an individual player sends out in and of itself is unlikely to capture how effective their communication with their teammates is, since this number could be driven by just one player being very vocal. We therefore capture communication as the average of this measure across all the players on the team.

Collaborative Experience$_{ithg}$ – To measure the level of familiarity that players have with their teammates, we compute the pairwise experience working together for every pair of players in the team as the number of games they have played together, i.e., as members of the same team. For each player, we then capture collaborative experience as the average of this measure across their four teammates. Hence, unlike our communication variable, our collective experience variable varies within the same team depending on each player's experience with their teammates.

Control Variables

Table 1 lists each of the control variables and describes our measures for each of them. We measured a range of factors which may affect players' choices of heroes and may correlate with our measures of interest. We control for the hero's popularity beyond a team's recent opponents. While we expect the team's direct opponents to be the principal targets of imitation, teams do have broader visibility over the games played by other teams in their tournaments. Controlling for a hero's popularity in the broader population is important in order to avoid conflating recent opponents' use of heroes with the general popularity of heroes during tournaments (variable 2 in Table 1), which may increase a hero's salience to players.

We also control for factors relating to a hero's win rate, i.e., the extent to which teams who chose the focal hero tended to win, because more successful hero choices may be more likely to be selected. We control for the win rate of recent opponents when they used the focal hero for the same role (variable 1). We also control for the hero's win rate in the current tournament (variable 3). These win rate variables are set to 0.5 in cases where a hero was never selected in the games considered to compute the measure, reflecting that not observing a hero win or lose has a neutral impact on the choice to select it (beyond what is inferred from the lack of observation of the hero itself, which is captured in the variables above).

We account for learning through the focal team's own experience by controlling for a team's own recent hero choices to account for pre-existing tendencies in the team's hero choice patterns (variable 4) and the team's own win rate with the hero in recent games, which may affect the team's likelihood of choosing that hero again (variable 5). We also capture the focal player's experience with the hero (variable 6), their general professional experience in DOTA 2 (variable 7), and their experience in their specific role (variable 8). We also measure the focal player's own tendency to explore new heroes, both in terms of the number of heroes they have recently played (variable 9) and the distribution of games they played across the different heroes (variable 10).

We also capture the influence of the opponent's choices during hero selection in the focal game. Heroes are selected by teams in an alternating pattern. A team cannot pick a hero if it has already been picked by the opponent, or if it has been "banned" by any of the two teams. Each team can ban six heroes over the course of the hero selection process. We control for whether a hero was picked by the opponent (variable 11) or banned (variable 12)[9].

--- INSERT TABLE 1 ABOUT HERE ---

Fitting our focus on partial imitation, we set up our empirical strategy so that our estimates are driven by variation within teams in their propensity to select heroes recently selected by opponents for different roles. To do so, we include *team-game-hero fixed effects* (η_{tgh}) in our primary models. These fixed effects account for stable differences between different teams' propensity to choose a specific hero, or even differences in the same team's propensity to choose a hero across different games. Our estimates are therefore derived by comparing the propensity to choose *a specific hero* across the five roles of *the same team* during *a single game*. Our models include 12,024,366 observations and 2,504,560 fixed effects. Any characteristics that are common to the whole team in the focal game are accounted for, and we are focusing on factors which drive differences between different roles in a particular team's propensity to imitate the heroes chosen by competitors for these roles, in line with our theory.

The remaining concern from the perspective of identifying a causal relationship in our setting arises from the fact that the interdependence structure of a team is not randomly assigned. Hence, there may be unobservable factors linking a team's interdependence structure to its hero choices, that are unrelated to the imitation-related mechanisms we are interested in. Some aspects of our design also help mitigate this concern. First, we are focusing on the imitation of a specific set of competitors—recent opponents—and we examine differences between interdependence patterns in the focal team and in those competitors. While an organization determines its own interdependence structures, the differences in its patterns of interdependence with respect to recent opponents are not

[9] Dropping these heroes from the risk set for the focal game, i.e., removing the rows corresponding to these heroes from the data for the focal game, does not substantively alter the results.

in its control since the identity of those opponents is randomized. Note also that we capture each team's interdependence based on stable patterns that emerge over the period of time leading up to the focal game rather than during the focal game itself.

Second, the team-game-hero level fixed effects serve to limit the scope for plausible alternative explanations driven by unobserved heterogeneity. Our analyses are focused on estimating differences between the five roles of a team in a particular game in whether the team's propensity to choose a particular hero for that role is related to the degree to which the team's prior opponents chose that hero to fulfill the role, controlling for each player's prior preference for that hero, the generalized popularity of that hero at that time, and the various other factors shown in Table 1.

Our baseline econometric specification can be summarized as follows:

$$Hero\ Chosen_{ithg} = \beta_0 + \beta_1 * Prior\ opponents'use\ of\ hero_{ithg} + \beta_2 * Controls_{ithg} + \eta_{thg} + \varepsilon$$

where β_1 estimates the focal team's propensity to imitate hero choices made by recent opponents.

To test hypothesis 1, we implement the specification below:

$$\begin{aligned} Hero\ Chosen_{ithg} & \\ &= \beta_0 + \beta_1 * Prior\ opponents'use\ of\ hero_{ithg} + \beta_2 \\ &* Interdependence\ difference_{ithg} + \beta_3 * Prior\ opponents'use\ of\ hero_{ithg} \\ &* Interdependence\ difference_{ithg} + \beta_4 * Controls_{ithg} + \eta_{thg} + \varepsilon \end{aligned}$$

where β_3 estimates the moderating effect of interdependence mismatch, testing hypothesis 1.

To test hypotheses 2 and 3, we are interested in examining the role of communication and collaborative experience as enablers of imitation under varying levels of interdependence difference. To investigate this, we estimate a triple interaction of communication/collaborative experience with the interaction term indicated in the prior model. In practice, we estimate this by splitting the sample above and below the median interdependence difference, and considering the interaction between communication/collaborative experience and *prior opponents' use of hero*. Our expectation based on the hypotheses is that communication and collaborative experience should promote imitation more when the level of interdependence difference is high than when it is low. Our models feature robust standard errors multi-clustered at the team and game levels. They are estimated via OLS unless otherwise indicated.

RESULTS

Table 2 shows summary statistics and correlations for the variables of interest. The likelihood of a player choosing a particular hero is on average just under 1%, which is as expected given that there are 113 hero choices open to players in the game. Every one of these heroes is picked at least once in the data. The opponent's win rate when choosing the focal hero has a mean of approximately 0.5; this is as expected since it is the average across all possible heroes.

--- INSERT TABLE 2 ABOUT HERE ---

Table 3 shows the results from our regression analyses. Model 1 only includes the control variables. Model 2 introduces our principal independent variable, i.e. *Prior opponents' use of hero*, and Model 3 is the full specification which includes the team-game-hero fixed effects. The addition of these fixed effects causes some the control variables to drop out of the models because they are invariant at the level of a particular team in a particular game in relation to a particular hero, and thus collinear with the *team-game-hero* fixed effects. *Prior opponents' use of hero* has a positive relationship with the outcome ($p<0.001$). The size of the coefficient indicates that, if 10% more of the firm's prior opponents chose a hero for a specific role, the corresponding likelihood of that hero being chosen by the focal player for the same role in the focal game goes up by approximately 1.8% (from model 3). This coefficient establishes the baseline propensity of teams to engage in imitation.

Next, we consider how this baseline propensity is altered by the degree to which the focal player's interdependence with their teammates matches that of the role-equivalent players in recent opponents, in accordance with hypothesis 1. Model 4 of Table 3 introduces the interaction between *Prior opponents' use of hero* and *interdependence difference* but without the use of the team game hero fixed effects. Model 5 is the fully specified model that also includes these fixed effects. We observe that *interdependence difference* negatively moderates the relationship between *Prior opponents' use of hero* and the selection of that hero, i.e. as the focal player's interdependence patterns grow increasingly different from that of their prior opponents, their propensity to imitate the hero choices of those prior opponents declines ($p<0.001$ from model 5). The magnitude indicates that a standard deviation increase in the interdependence difference between a player and their prior opponents leads to the marginal effect of *Prior opponents' use of hero* on the choice of hero declining by about 27%. These results offer support for hypothesis 1. Figure 2 shows a plot of the interaction.

On average, the difference between the maximum and minimum values of *interdependence difference* within the same team in the same match is the equivalent of three-quarters of a standard deviation. This implies that for the average team, the effect of *Prior opponents' use of hero* on the hero choice of one player is 21% greater than the equivalent for another player *on the same team*, as a result of the interdependence structures within which they are embedded. In line with the arguments that motivated our study, these findings show substantial variance in the propensity to imitate competitors' choices related to different strategy components—in this case choices about different roles within a team—and show that this variation can be driven by the pattern of interdependencies between these components. As a result, different teams exposed to the same competitor systematically differ in which of the competitor's choices they imitate.

--- INSERT TABLE 3 AND FIGURE 2 ABOUT HERE ---

Next, we consider the impact of communication in enabling imitation, and specifically how it varies depending on the level of mismatch in interdependence patterns of the focal role between a team and its recent opponents. To test this, we consider a triple interaction of communication with the previously modeled interaction between *interdependence difference* and *Prior opponents' use* *of hero*. To aid interpretation, we implement this analysis by a split sample approach with simultaneous estimation. We split the sample at the median value of interdependence difference and compare the interaction between *Communication* and *Prior opponents' use of hero* across the two (jointly estimated) models. Model 6 shows the results for the sub-sample that has low interdependence difference, and Model 7 shows the results for the sub-sample that has high interdependence difference, in both cases without the team-game-hero fixed effects. Models 8 and 9 show the equivalent models with the fixed effects. We observe a positive interaction between *Communication* and *Prior opponents' use of hero* in Models 7 and 9 that is greater in magnitude and statistical significance than the equivalent in Models 6 and 8 respectively. Wald tests shows that these differences are meaningful (p=0.055 without FE, p = 0.012 with FE). These results provide support for our hypothesis 2: communication plays a more substantial role in facilitating component-level imitation when there are greater differences between a team and its recent opponents in the pattern of interdependencies surrounding the focal role.

--- INSERT TABLE 4 ABOUT HERE ---

Our final hypothesis relates to the role of collaborative experience, with our expectation being that greater collaborative experience could serve as an antidote to the dampening effect of mismatched interdependencies on component-level imitation. We test this in an analogous manner to the prior analyses on communication. The results are shown in table 5. Model 10 shows the interaction between *Collaborative experience* and *Prior opponents' use of hero* for the sub-sample with low (i.e. below median) interdependence difference, and Model 11 shows the results for the sub-sample with high interdependence difference, in each case without the team-game-hero fixed effects. Models 12 and 13 include these fixed effects. As in the previous case, we observe that the interaction effect is positive, stronger, and more significant at high levels of interdependence difference, with the difference in the coefficients between the two models statistically different to each other in each case when simultaneously estimated (p<0.001 in each case). These results provide support for hypothesis 3: collaborative experience plays a more substantial role in facilitating component-level imitation when there are more pronounced differences in the focal role's interdependence patterns between an organization and its competitors.

--- INSERT TABLE 5 ABOUT HERE ---

Additional Tests

We carried out several tests to examine whether our results are sensitive to model specifications or the specific measures we employ. We briefly outline these below; detailed descriptions and full results are shown in the online appendix.

a) In our main analyses, we employed a vector measure of interdependence difference that enabled us to distinguish players based on which specific other roles in their team they are interdependent with. We also check the robustness of these findings to a more basic measure of interdependence difference based just on the degree to which a player is interdependent with their teammates. For each player, we calculate the average number of other teammates involved in the sequences of actions they participate in. We then determine the absolute difference of this with the player playing in the equivalent role in the prior opponents' teams to obtain *interdependence difference scalar*. Replicating the analyses using this measure provides results that are meaningfully unaltered from those in the main analyses.

b) As previously described, DOTA tournaments feature two phases: the initial round-robin phase where teams are randomly assigned into groups in which they play against every other team, followed by a knock-out phase. While teams have no control over the identity of their opponents in either phase, the latter knock-out phase leaves out the poorer performing teams from the previous round. As a more stringent test of our hypotheses, we re-examine our results excluding all matches that could be from the knock-out phase, i.e., only including those from the fully randomized round-robin phase, and find them to be meaningfully unaltered.

c) Our analyses capture imitation by examining the focal player's choice of hero in relation to the player in that role in the focal team's previous 20 games. We also examined the robustness of the results to using two alternative windows of prior games by which to characterize imitation – 10 games, and 30 games. The results across all models are highly consistent with those we obtained using a 20-game window.

d) The outcome variable in our analyses (*Hero chosen*) is binary, indicating whether the focal hero is chosen by the focal player or not. Such outcomes are commonly modeled using approaches that are conducive to the representation of nonlinear relationships, such as a probit or logit regression. We have employed linear models estimated via OLS as our main specification in the interest of consistency and interpretability. However, the results are also robust to the use of logit models, and all our hypotheses continue to be supported in this specification.

DISCUSSION

In this study, we set out to investigate why different organizations imitate different components of their competitors' strategies. Building on computational work in the evolutionary tradition, we argued that the structure of interdependencies between different activities plays a substantial role in shaping imitation between competitors. When an organization and its competitor differ in how a given component of their strategy interacts with others, the consequences of replicating the competitor's choices in relation to this component become less predictable for the imitator. This makes the organization less likely to imitate that choice unless its decision-makers can rely on coordination mechanisms to resolve this unpredictability. We theorized that communication and collaborative experience can both provide such mechanisms.

We tested our theory in esports, where small teams of professional video game players compete in high-stakes tournaments. The setting provided us with highly granular data on the choices made about different roles in a team, the interdependence structures between these roles, and the ways players coordinate with each other. The design of the tournaments with randomized allocation of teams into groups provides exogenous variation in the strategies to which each team is exposed, helping us isolate the impact of internal interdependencies on imitation. We find that a team is more likely to choose a hero for a specific role when the hero has been more widely employed by its recent opponents for the same role, and that this relationship declines when the pattern of interdependence between this role and others is more different between the team and recent opponents. This generates substantial variation within teams in the degree to which they imitate their competitors' choices about different roles. However, the degree to which mismatched interdependencies curtails imitation is also moderated by coordination mechanisms within the team. Both the frequency of communication and the collaborative experience between teammates promote imitation substantially more when the interdependency mismatch with recent opponents is higher.

Before outlining the contributions of our study, we note some of its limitations. While several virtues of our empirical setting enabled us to study the questions that are at the heart of this paper, other aspects of this setting may raise some uncertainty about the generalizability of our findings. One significant boundary condition concerns the degree to which organizations are able to observe each other's choices and internal processes. In DOTA 2, teams can directly observe not only the heroes their opponents choose but also the task structures within which opponents deploy these heroes. Put differently, they can observe both the choices made by their competitors about different strategy components and the pattern of interdependencies between these components. On the one hand, this aspect of our context helps back our claim that our theory can explain variation in imitation behavior even when competitors are able to perfectly observe each other's choices and the interdependencies among them—which constitutes a meaningful addition to existing explanations. On the other hand, more conventional organizations vary in the extent to which their internal interdependencies are directly visible to stakeholders and competitors. Organizations can gain information about each other's internal processes when these processes create a reputation (e.g., McCord, 2014) or leave public traces (e.g., Kim, 2019). Internal processes can also become visible when organizations partner with each other (e.g., Inkpen and Tsang, 2007), or via informal industry networks which may be developed through employee mobility, board interlocks, shared supplier or customer ties. (e.g. Corredoira and Rosenkopf, 2010). Through these and other means, decision makers in most organizations develop a perception of the internal setups of their competitors (Gur and Greckhamer, 2019). These perceptions may vary in their levels of accuracy and fidelity (Bloodgood and Bauerschmidt, 2002; Tsai, Su, and Chen, 2011). We anticipate that our arguments here apply to the perceived structure of the target of imitation, i.e., that a mismatch in this perceived structure to one's own act as a drag on imitation, and that stronger coordination mechanisms can alleviate this drag. This should be the case regardless of the degree to which those perceptions match reality. Our theory establishes an important baseline and empirically tests it in a context where managers are able to directly observe competitors' internal linkages. We anticipate that further research efforts will help us understand more precisely how the strength and uniformity of these perceptions within an organization may moderate these mechanisms

Another concern is whether the empirical patterns identified in our analysis truly reflect strategic imitation, which has been defined as a *purposeful* attempt to reproduce competitors' choices (Posen *et al.*, 2023). Inferring purpose from empirical data is difficult, and there is always the possibility that our observed patterns may be driven by broader changes that happen to affect different organizations at different times. For instance, two organizations may converge on a practice around the same time due to some systematic shifts in broader environmental or technological conditions. While we cannot categorically rule out the possibility of it playing a role in our findings, we believe our unique empirical setting provides significant advantages in isolating imitation. We restrict comparisons tightly to be between the five players of the same team in the same game, limiting the scope for the differences in the effects we observe to be driven by systematically heterogeneous influences that affect only specific players. We also focus on imitation in a randomized group of competitors, making it unlikely that the specific pairings of competitors we examine are systematically subject to distinctive influences that shape their hero choices. We also study a fully observable environment which lets us measure a range of potential confounds such as broad trends in hero choices characterizing the universe of DOTA 2 gameplay or even the specific tournament. We can also precisely control for the prior behavior of the focal team and player. Our extensive qualitative fieldwork also helped us assess the face validity of our mechanisms of interest in this setting[10].

Despite these limitations, our study makes contributions to several literatures concerned with imitation among competitors. First, we make a theoretical contribution to the emerging literature on partial imitation by providing a novel explanation that helps predict both *whether* and *what* competitors imitate from each other. While prior research had highlighted how interdependence among the components of an organization's strategy can allow it to deter imitation by competitors (e.g., Ethiraj *et al.*, 2008; Lippman and Rumelt, 1982; Rivkin, 2001), we suggest that it can also affect its own propensity to engage in imitation and what it imitates. Our theory has the potential to explain a range of behavioral patterns of interest to strategy scholars. It helps explain why the

[10] We consulted public sources (written publications and video documentaries featuring live recordings of teams at play) and engaged in our own fieldwork, which involved more than 150 hours of direct observation of teams during tournaments in the United States, Canada, and Poland. Our fieldwork included interviews with professional players, tournament organizers, and analysts. Additionally, one of the authors spent more than 1,000 hours playing DOTA 2, including 50 hours playing with professional players, to better understand the game's mechanics.

propensity to engage in imitation can vary systematically both between and within organizations, and it allows us to explain why this variation can be observed even when competitors are able to perfectly observe each other's choices and the interdependencies among them. Ultimately, these insights add to the theoretical toolkit available to strategy scholars can use to explain heterogeneity between competitors—a fundamental question for strategy research (Rumelt *et al.*, 1994).

Second, our work generates methodological advances that are relevant both to the literature on strategic imitation and to the evolutionary perspective on organizational search whose computational models were the conceptual basis for our theorizing. While the computational tradition has generated very influential theory, research that facilitates a clear empirical translation of these models is still a work in progress (e.g., Billinger, Stieglitz, and Schumacher, 2014; Clement, 2023). DOTA 2 provides a promising context in this regard given that teams face a decision context that maps onto the task environment conceptualized in many models of search, particularly NK models, where actors make choices about different components with varying patterns of interdependence—which our data allow us to measure. Econometrically, this setting also provides advantages by allowing us to use fixed effects at the team-game-hero level and draw inferences from internal variation in adoption behavior within a single team at a particular point in time. The setting also provides a source of exogenous variation in the competitors' choices to which each team is exposed via randomized assignment of teams into groups in tournaments, which helped us distinguish the drivers of imitation from the drivers of exposure.

Finally, some by-products of our work may inform literatures beyond that on strategic imitation. In the literature on organization design, for instance, a recent stream of empirical studies has taken a micro-analytic approach to understand the impact of organization design on decision-making (e.g., Billinger *et al.*, 2021; Raveendran, Puranam, and Warglien, 2016). These studies share an emphasis on small organizational aggregates—teams or even individual decision-makers—and on mechanisms whose relevance in larger organizations is plausible. We add to this stream of research by generating micro-level insights on the intra-organizational factors leading to strategic imitation. Examining our phenomenon of interest at a high level of fidelity within small teams helped us pinpoint the coordination mechanisms we theorized about and helped us isolate mechanisms which may plausibly operate in larger and more complex organizations—although they may be moderated by other factors in these settings. Investigating these factors is an opportunity for future research. Our insights may also inform the literature on the inter-organizational diffusion of practices, whose scholars have primarily conceptualized diffusion as occurring between unitary actors (see Naumovska *et al.*, 2021 for a review). Our work helps understand diffusion as a phenomenon occurring between specific parts of organizations rather than their entirety and pinpoint internal factors that affect it. Our findings may help explain why some practices and technologies spread through populations and others do not, as well as the paths along which they are most likely to spread.

In conclusion, our study generates a set of insights which advance scholarly understanding of strategic imitation. Our findings complement prior research by suggesting that the degree to which organizations imitate the choices of others is affected not only by environmental factors but also by their internal design—specifically the nature of the interdependencies and the coordination mechanisms that exist within them. Our hope is that this study paves the way for future research examining a wider range of internal factors and their impact on strategic imitation.

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Table 1: Control Variables

	Control Variable	Measurement
1	Prior opponents' win rate using hero	Percentage of wins by the opponents in the last 20 games who picked this hero for the same role
2	Hero use in current tournament (by any team)	Percentage of games in the current tournament in which this hero was picked
3	Hero win rate in current tournament	Percentage of wins when this hero was picked in the current tournament
4	Hero use by team	Percentage of last 20 games where the focal team picked this hero
5	Hero team win rate	Percentage of wins when this hero was picked by the focal team in its last 20 games
6	Player experience with hero	Number of games this player has ever played using this hero
7	Player experience	Player’s number of professional games ever played
8	Player experience in this role	Player’s number of professional games ever played in this role
9	Player variation in hero choices	Herfindahl index-based measure of the diversity of heroes chosen by this player in the last 20 games
10	Player number of different heroes chosen	The number of different heroes chosen by this player in the last 20 games
11	Current opponent chose hero	Binary variable indicating that the hero was chosen by the team's opponent in the focal game
12	Current opponent banned hero	Binary variable indicating that the hero was 'banned' by the team's opponent in the focal game.

Table 2: Summary Statistics and Correlations

Sl	Variables	Mean	SD	Min	Max	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	Hero Chosen	0.01	0.09	0	1	1.00																
2	Prior opponents' use of hero	0.01	0.05	0	1	0.10	1.00															
3	Interdependence difference	0.15	0.12	0	1.41	0.00	0.00	1.00														
4	Communication	0.75	0.30	0.03	2.05	0.00	0.00	-0.15	1.00													
5	Collaborative Experience	1.03	1.21	0.00	9.53	0.00	0.00	-0.28	0.17	1.00												
6	Prior opponents' win rate using hero	0.49	0.14	0	1.00	0.00	-0.12	0.00	-0.02	-0.01	1.00											
7	Hero use in current tournament (by any tear	0.08	0.10	0	1	0.10	0.20	-0.05	0.02	0.05	-0.03	1.00										
8	Hero win rate in current tournament	0.48	0.22	0	1	0.01	0.01	-0.01	0.01	0.01	0.02	0.06	1.00									
9	Hero use by team	0.05	0.10	0	1	0.10	0.09	0.00	0.00	0.00	0.00	0.43	0.04	1.00								
10	Hero team win rate	0.51	0.23	0	1	0.04	0.01	0.02	0.02	0.00	-0.02	0.04	0.06	0.16	1.00							
11	Player experience with hero	2.96	9.00	0	238	0.10	0.11	-0.10	0.10	0.23	-0.03	0.10	0.01	0.08	0.01	1.00						
12	Player variation in hero choices	0.15	0.22	0.05	1	0.00	0.00	0.52	-0.18	-0.31	0.01	-0.05	-0.02	0.00	0.01	-0.12	1.00					
13	Player number of different heroes chosen	39.3	25.6	1	104	0.00	0.00	-0.42	0.32	0.56	-0.01	0.06	0.02	0.00	0.00	0.27	-0.54	1.00				
14	Player experience	3.27	3.35	0.01	14.1	0.00	0.00	-0.30	0.28	0.69	-0.02	0.05	0.01	0.00	0.01	0.34	-0.36	0.81	1.00			
15	Player experience in this role	1.33	1.68	0	10.9	0.00	0.00	-0.25	0.21	0.61	-0.01	0.04	0.01	0.00	0.01	0.27	-0.29	0.59	0.81	1.00		
16	Current opponent chose hero	0.04	0.21	0	1	-0.02	0.06	0.00	0.00	0.00	-0.01	0.21	0.02	0.11	0.01	0.02	0.00	0.00	0.00	0.00	1.00	
17	Current opponent banned hero	0.04	0.21	0	1	-0.02	0.05	0.00	0.00	0.00	0.00	0.21	0.04	0.20	0.07	0.03	0.00	0.00	0.00	0.00	-0.05	1.00

Pairwise correlations based on 12M observations

Table 3: Impact of Asymmetries in Interdependence on Component Level Imitation

DV: Hero Chosen	Model 1		Model 2		Model 3		Model 4		Model 5	
	Coef.	p. val	Coef.	p. val	Coef.	p. val	Coef.	p. val	Coef.	p. val
Prior opponents' use of hero			0.1498 (0.0069)	0.0000	0.1766 (0.0075)	0.0000	0.2519 (0.0093)	0.0000	0.2971 (0.0097)	0.0000
Interdependence difference	0.0007 (0.0001)	0.0000	0.0006 (0.0001)	0.0000	0.0002 (0.0001)	0.0019	0.0047 (0.0002)	0.0000	0.0053 (0.0002)	0.0000
Interdependence difference x Prior opponents' use of hero							-0.4215 (0.0203)	0.0000	-0.5143 (0.0219)	0.0000
Communication	-0.0002 (0.0001)	0.0248	-0.0002 (0.0001)	0.0433			-0.0002 (0.0001)	0.0446		
Collaborative experience	-0.0001 (0.0000)	0.0012	-0.0001 (0.0000)	0.0035	0.0000 (0.0000)	0.9915	-0.0001 (0.0000)	0.0057	0.0000 (0.0000)	0.9467
Prior opponents' win rate using hero	0.0010 (0.0008)	0.2346	0.0071 (0.0007)	0.0000	0.0063 (0.0008)	0.0000	0.0070 (0.0007)	0.0000	0.0061 (0.0007)	0.0000
Hero use in current tournament (by any team)	0.0731 (0.0017)	0.0000	0.0598 (0.0021)	0.0000			0.0560 (0.0021)	0.0000		
Hero win rate in current tournament	0.0026 (0.0001)	0.0000	0.0027 (0.0001)	0.0000			0.0027 (0.0001)	0.0000		
Hero use by team	0.0634 (0.0019)	0.0000	0.0635 (0.0018)	0.0000			0.0627 (0.0018)	0.0000		
Hero team win rate	0.0107 (0.0002)	0.0000	0.0109 (0.0002)	0.0000			0.0110 (0.0002)	0.0000		
Player experience with hero	0.0011 (0.0000)	0.0000	0.0010 (0.0000)	0.0000	0.0011 (0.0001)	0.0000	0.0010 (0.0000)	0.0000	0.0011 (0.0001)	0.0000
Player experience	-0.0010 (0.0000)	0.0000	-0.0009 (0.0000)	0.0000	-0.0011 (0.0001)	0.0000	-0.0009 (0.0000)	0.0000	-0.0010 (0.0000)	0.0000
Player experience in this role	-0.0000 (0.0000)	0.9172	0.0000 (0.0000)	0.0018	0.0000 (0.0000)	0.0000	0.0000 (0.0000)	0.0000	0.0001 (0.0000)	0.0000
Player variation in hero choices	0.0008 (0.0001)	0.0000	0.0007 (0.0000)	0.0000	0.0001 (0.0000)	0.0000	0.0006 (0.0000)	0.0000	0.0002 (0.0000)	0.0000
Player number of different heroes chosen	-0.0000 (0.0000)	0.0000	-0.0000 (0.0000)	0.0000	0.0000 (0.0000)	0.0026	-0.0000 (0.0000)	0.0001	0.0000 (0.0000)	0.0015
Current opponent chose hero	-0.0230 (0.0002)	0.0000	-0.0237 (0.0002)	0.0000			-0.0238 (0.0002)	0.0000		
Current opponent banned hero	-0.0269 (0.0003)	0.0000	-0.0271 (0.0003)	0.0000			-0.0271 (0.0003)	0.0000		
Team - Game - Hero Fixed Effects	N		N		Y		N		Y	
Num. Observations	12M		12M		12M		12M		12M	
R - squared	0.0274		0.0333		0.2182		0.0348		0.2198	

Standard errors shown in parentheses are robust and dual clustered at the level of the team and the match. The coefficients associated with Communication and a number of other controls are not estimated in models 3 and 5 because the measures are collinear with the team-game-hero fixed effects.

Table 4: Communication as an Aid to Imitation Under Varying Interdependence Difference

DV: Hero Chosen	Model 6		Model 7		Model 8		Model 9	
	Interdep. Diff: low		**Interdep. Diff: high**		**Interdep. Diff: low**		**Interdep. Diff: high**	
	Coef.	p. val	Coef.	p. val	Coef.	p. val	Coef.	p. val
Prior opponents' use of hero	0.2341	0.0000	0.0531	0.0000	0.3088	0.0000	0.0590	0.0000
	(0.0155)		(0.0081)		(0.0167)		(0.0091)	
Communication	-0.0006	0.0009	-0.0010	0.0000				
	(0.0002)		(0.0002)					
Communication x Prior opponents' use of hero	**0.0461**	**0.0107**	**0.0811**	**0.0000**	**0.0329**	**0.1006**	**0.0877**	**0.0000**
	(0.0180)		**(0.0134)**		**(0.0200)**		**(0.0149)**	
Collaborative experience	-0.0001	0.1142	-0.0001	0.0000	0.0000	0.7900	-0.0000	0.3592
	(0.0000)		(0.0000)		(0.0000)		(0.0000)	
Interdependence difference	-0.0019	0.0000	0.0007	0.0000	-0.0026	0.0000	0.0004	0.0000
	(0.0004)		(0.0001)		(0.0003)		(0.0001)	
Prior opponents' win rate using hero	0.0072	0.0000	0.0068	0.0000	0.0064	0.0000	0.0058	0.0000
	(0.0008)		(0.0010)		(0.0009)		(0.0011)	
Hero use in current tournament (by any team)	0.0399	0.0000	0.0703	0.0000				
	(0.0017)		(0.0023)					
Hero win rate in current tournament	0.0025	0.0000	0.0028	0.0000				
	(0.0002)		(0.0002)					
Hero use by team	0.0830	0.0000	0.0537	0.0000				
	(0.0020)		(0.0016)					
Hero team win rate	0.0104	0.0000	0.0117	0.0000				
	(0.0003)		(0.0003)					
Player experience with hero	0.0009	0.0000	0.0010	0.0000	0.0010	0.0000	0.0011	0.0000
	(0.0000)		(0.0001)		(0.0000)		(0.0001)	
Player experience	-0.0009	0.0000	-0.0009	0.0000	-0.0010	0.0000	-0.0010	0.0000
	(0.0000)		(0.0000)		(0.0000)		(0.0001)	
Player experience in this role	0.0001	0.0000	0.0000	0.0683	0.0001	0.0000	0.0000	0.0000
	(0.0000)		(0.0000)		(0.0000)		(0.0000)	
Player variation in hero choices	0.0007	0.0000	0.0006	0.0000	0.0004	0.0000	0.0001	0.0004
	(0.0001)		(0.0000)		(0.0001)		(0.0000)	
Player number of different heroes chosen	-0.0000	0.6770	-0.0000	0.0000	0.0000	0.0001	0.0000	0.0685
	(0.0000)		(0.0000)		(0.0000)		(0.0000)	
Current opponent chose hero	-0.0251	0.0000	-0.0228	0.0000				
	(0.0003)		(0.0002)					
Current opponent banned hero	-0.0293	0.0000	-0.0258	0.0000				
	(0.0003)		(0.0003)					
Team - Game - Hero Fixed Effects	N		N		Y		Y	
Num. Observations	5.9M		6.1M		5.5M		5.7M	
R - squared	0.0410		0.0291		0.2843		0.2832	

Standard errors shown in parentheses are robust and dual clustered at the level of the team and the match. Models 6 and 8 are sub-samples that are below the sample median interdependence difference, and models 7 and 9 are the sub-samples with above median interdependence difference. Simultaneous estimation shows the coefficients on the interaction terms in models 6 and 7 are statistically distinct from each other, as are the equivalent coefficients in models 8 and 9.

Table 5: Collaborative Experience with Teammates as an Aid to Imitation Under Varying Interdependence Difference

DV: Hero Chosen	Model 10		Model 11		Model 12		Model 13	
	Interdep. Diff: low		**Interdep. Diff: high**		**Interdep. Diff: low**		**Interdep. Diff: high**	
	Coef.	p. val	Coef.	p. val	Coef.	p. val	Coef.	p. val
Prior opponents' use of hero	0.2589	0.0000	0.0863	0.0000	0.3421	0.0000	0.0946	0.0000
	(0.0116)		(0.0045)		(0.0120)		(0.0046)	
Collaborative experience	-0.0001	0.2500	-0.0008	0.0000	0.0001	0.4298	-0.0008	0.0000
	(0.0001)		(0.0002)		(0.0001)		(0.0002)	
Collaborative experience x Prior opponents' use of hero	**0.0094**	**0.3405**	**0.0662**	**0.0000**	**-0.0072**	**0.4139**	**0.0784**	**0.0000**
	(0.0099)		**(0.0135)**		**(0.0088)**		**(0.0155)**	
Communication	-0.0002	0.0641	-0.0002	0.0360				
	(0.0001)		(0.0001)					
Interdependence difference	-0.0019	0.0000	0.0007	0.0000	-0.0026	0.0000	0.0004	0.0000
	(0.0004)		(0.0001)		(0.0003)		(0.0001)	
Prior opponents' win rate using hero	0.0072	0.0000	0.0072	0.0000	0.0063	0.0000	0.0064	0.0000
	(0.0008)		(0.0009)		(0.0009)		(0.0010)	
Hero use in current tournament (by any team)	0.0398	0.0000	0.0673	0.0000				
	(0.0017)		(0.0024)					
Hero win rate in current tournament	0.0025	0.0000	0.0028	0.0000				
	(0.0002)		(0.0002)					
Hero use by team	0.0830	0.0000	0.0536	0.0000				
	(0.0020)		(0.0015)					
Hero team win rate	0.0104	0.0000	0.0117	0.0000				
	(0.0003)		(0.0003)					
Player experience with hero	0.0009	0.0000	0.0009	0.0000	0.0011	0.0000	0.0011	0.0000
	(0.0000)		(0.0000)		(0.0000)		(0.0001)	
Player experience	-0.0009	0.0000	-0.0009	0.0000	-0.0010	0.0000	-0.0010	0.0000
	(0.0000)		(0.0000)		(0.0000)		(0.0000)	
Player experience in this role	0.0001	0.0000	0.0000	0.0039	0.0001	0.0000	0.0001	0.0000
	(0.0000)		(0.0000)		(0.0000)		(0.0000)	
Player variation in hero choices	0.0007	0.0000	0.0006	0.0000	0.0004	0.0000	0.0001	0.0000
	(0.0001)		(0.0000)		(0.0001)		(0.0000)	
Player number of different heroes chosen	-0.0000	0.7794	-0.0000	0.0000	0.0000	0.0001	0.0000	0.0073
	(0.0000)		(0.0000)		(0.0000)		(0.0000)	
Current opponent chose hero	-0.0251	0.0000	-0.0229	0.0000				
	(0.0003)		(0.0002)					
Current opponent banned hero	-0.0293	0.0000	-0.0257	0.0000				
	(0.0003)		(0.0003)					
Team - Game - Hero Fixed Effects	N		N		Y		Y	
Num. Observations	5.9M		6.1M		5.5M		5.7M	
R - squared	0.0410		0.0299		0.2843		0.2839	

Standard errors shown in parentheses are robust and dual clustered at the level of the team and the match. Models 10 and 12 are sub-samples that are below the sample median interdependence difference, and models 11 and 13 are the sub-samples with above median interdependence difference. Simultaneous estimation shows the coefficients on the interaction terms in models 10 and 11 are statistically distinct from each other, as are the equivalent coefficients in models 12 and 13

Figure 1: Component choices and interdependencies in an organization and its competitors

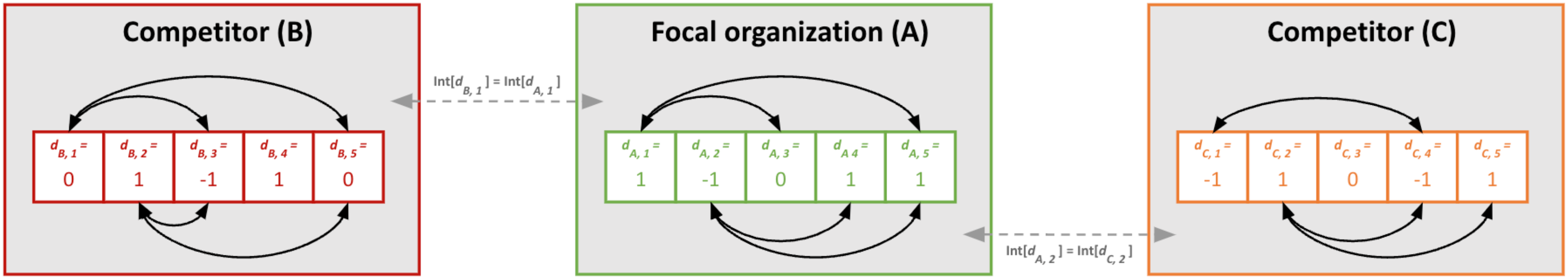
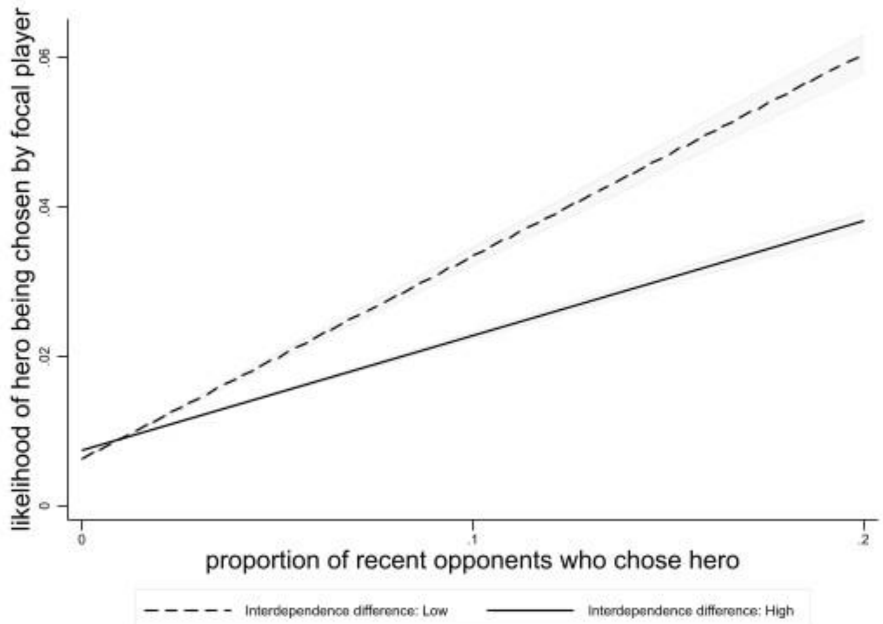


Figure 2: Interaction Plot Showing Variation in Component-level Imitation based on Interdependence Difference



Plot based on estimates from model 5 of table 3. High and low interdependence difference are defined at the 90th and 10th percentile respectively. Shaded area shows 90% confidence intervals. Range of X-axis extends to the 99th percentile in the data.