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The Price for Market Embeddedness is Declining Adaptive Capabilities: Model, Measurement and Illustration

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This paper deals with a central challenge in organization and management research: to predict the evolution of an organization's adaptive capability. We address both theoretical and methodological gaps in existing research. First, focusing on the largely overlooked external constraints on adaptive capability, we model how ties between an organization and its market audiences curtail adaptive capability as market tenure increases. Second, we address the methodological weakness of conceptualizing the content of organizational change in prior research with a novel approach. Our distance-based approach sees adaptation as change in an organization's position in a cognitive market space. With position defined, one can measure the speed of movement in that space. An analysis of the UK motorcycle market serves as an empirical illustration for our theoretical prediction and proposed measure.

Introduction

A central challenge in organization and management research is to predict the evolution of adaptive capability, that is an organization's capability to adapt to environmental changes (Levinthal, 1991; Rosenbloom and Christensen, 1994). Because the environment provides resources necessary for an organization's operation, an organization's fate is perpetually determined by its capability to adapt to and remain aligned with its environment (Pfeffer and Salancik, 1978). We have learned from existing research that the evolutionary trajectory of adaptive capability significantly affects employees' wellbeing (Dahl, 2011), employment relations (Hannan, Burton and Baron, 1996), organizational performance (Klarner and Raisch, 2013), innovation output (Sørensen and Stuart, 2000) and the functioning of essential sectors (Buchanan *et al.*, 2005).

Although a considerable body of work has addressed adaptive capability, two gaps remain: one theoretical and the other methodological. First, researchers have long recognized that adaptive capability is driven by forces both within the organization and at its interface with external audiences (e.g. users, customers, suppliers, intermediators, investors and regulators) (Christensen and Bower, 1996; Gilbert, 2005; Hannan and Freeman, 1977). Yet, existing research has mostly focused on the internal forces and how they

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vary with organizational age. Researchers argue that organizational learning (Levinthal, 1991; March, 1991; Nelson and Winter, 1982), organizational memory (Levitt and March, 1988; March, Schulz and Zhou, 2002) and internal resistance to change (Le Mens, Hannan and Pólos, 2015b) affect adaptive capability as organizations grow older. This largely inward-looking view results in various predictions of how organizational age affects mortality hazard, ranging from liabilities of newness (Stinchcombe, 1965) to liabilities of obsolescence (Barron, West and Hannan, 1994).

Our in-depth understanding of the internal forces stands in stark contrast to our scant insight on the external forces, of which the ties at the organization-market interface are especially relevant. Market ties are the channels of exchanging goods, services and money, which are resources critical to the continued operation and survival of organizations (Baker, 1990; Broschak and Block, 2014). The neglect of the organization-market interface matters because it cripples our ability to address several puzzling questions of both academic and practical relevance. Why have incumbent organizations often starved efforts to enter new market segments, even while the organization has understood the urgent need to adapt (Gilbert, 2005)? Why do organizations carrying out apparently straightforward changes of internal features have difficulty remaining committed to the changing task and thus fail to adapt (Christensen and Bower, 1996)?

Second, existing research has yet to conceptualize and measure a fundamental concept: the content of organizational change. There is a clear consensus that both the content of change (i.e. what has been changed) and the process of change (i.e. how change takes place) are critical for understanding adaptation (Barnett and Carroll, 1995; Levinthal, 1991). Existing studies have largely concentrated on the aspects of process such as frequency, sequence or rhythm of change (e.g. Haveman, 1992; Klarner and Raisch, 2013; Vermeulen and Barkema, 2002). The content of change, however, has lacked proper conceptualization (Carroll and Hannan, 2000, p. 373) or even been assumed away because 'measuring and integrating such distinctiveness poses a challenge' (Greve, 2011, p. 107). This is worrying because we have compelling evidence that failing to account for both process and content may lead to flawed conclusions about adaptive capability (Sørensen and Stuart, 2000).

We aim to contribute to the research on adaptive capability by addressing both the theoretical and methodological gaps. First, we contribute to a better understanding of how ties at the organizationmarket interface affect adaptive capability. We contend that the strength of such ties depends on the organization's tenure in a market (an organization can have multiple market interfaces with varying market tenures), rather than organizational age (which is the focus of most existing studies concentrating on the internal forces). Our outwardlooking model is driven by a different clock, market tenure. In today's densely interdependent environment, 'the dominant problems of the organization have become managing its exchanges and its relationships with the diverse interests affected by its actions' (Pfeffer and Salancik, 1978, p. 94).¹ This study fills a gap between the growing dependence of contemporary organization on its market audiences and the dearth of research on how organization-market interface ties affect adaptive capability.

Second, our study tackles the methodological challenge of conceptualizing the content of organizational change. Our approach is embedded in the recent socio-cognitive turn in organizational theory, that studies organizations 'in terms of their social meanings and interpretation given to them by contemporaneous actors' (Hannan, Pólos and Carroll, 2007, p. 31). If we define portfolios of organizational offers across market categories in a cognitive space (i.e. a space of meaning; see also Hannan et al., 2019), adaptation can be seen as an organization's speed of movement in that space (Le Mens, Hannan and Pólos, 2015b). Our (cognitive) distance-based measure provides a solution to the challenge of measuring differences among market categories in conceptualizing content of change (Greve, 2011).

¹The recent Covid-19 crisis has exposed the extensive dependency of organizations on the market environment and put their adaptive capability to the test, as factories faced mass order cancellations because of drastically changing consumer behaviour (Bloomberg, 2020) and as firms encountered dire problems of supply-chain breakdown (BBC, 2020; Moyo, 2020).

Adaptive capability: definition and measurement

Existing research

Existing research has centred on the process of change (Beck, Brüderl and Woywode, 2008; Klarner and Raisch, 2013; Vermeulen and Barkema, 2002), while largely failing to specify the content of change. Carroll and Hannan (2000, p. 373) point out that 'theoretical ideas are rarely applied to conceptualize the content in studies assessing the effects of change. Instead, measures of the content of change are usually taken as given and treated as control variables'. Insufficient specification of the content of change may expose researchers to misleading conclusions. One example concerns the two apparently contradictory consequences of aging for organizational innovation (Sørensen and Stuart, 2000). From a process point of view, older firms seem to be more innovative because they file for patents at a higher frequency. From a content point of view, younger firms may be more innovative because their patents often contain more significant advancement over prior art. However, researchers encounter significant challenges in conceptualizing the content of change. Unable to account for the content of change while measuring shipping firms' strategic repositioning across the nine ship categories, Greve (2011, p. 107) admits 'a drawback of this measure is that it treats all categories of ships as equally different from each other'.

We respond to the challenge with a distancebased approach. Because many existing studies view organizational change as changes across categories (Greve, 2011; Haveman, 1992; Vermeulen and Barkema, 2002), our approach builds on the fast-growing literature on categories in markets (Hannan, 2010; Hannan et al., 2019; Hsu and Grodal, 2015; Zuckerman, 1999). Categories are fundamental to how we perceive the world, process information, make decisions and interact with each other. We rely on categories for attending cultural and leisure activities (Zuckerman and Kim, 2003), for making consumption decisions (Hsu and Grodal, 2015), for planning business and market entry strategies (Porac and Thomas, 1990), for making hiring and investment choices (Zuckerman, 1999; Zuckerman et al., 2003) and of course also for decisions concerning organizational change.

A distance-based approach

Because of the importance of categories in social life and market activities, organizational adaptation is often depicted as changes of its offer portfolio across categories. For example, the shipping market comprises categories of container, cruise, passenger except cruise, general cargo and tanker (Greve, 2011). The loan and credit market has investment categories like residential mortgages, non-residential mortgages, consumer nonmortgages and commercial non-mortgages (Haveman, 1992). The car market categories include economy car, luxury car, SUV and minivan. Market categories represent the shared understanding between producers and audiences. By grouping products and services into meaningful cognitive classes, categories ease valuation and transactions at the organization-market interface (Rosa et al., 1999; Zuckerman, 1999). To its market audiences, an organization and its adaptation can be characterized by its offer portfolio across categories.

Organizational capability accounts for an organization's ability to perform certain activities (Dosi, Nelson and Winter, 2000). Both researchers and practitioners relate being adaptive to flexibility, agility and speed (Chakravarthy, 1982; Peters and Waterman, 1982; Siggelkow and Rivkin, 2005). Adaptive capability, in fact, is about how quickly an organization is *able* to change its offer portfolio to adapt to environmental shifts. We propose the following definition:

Definition 2.1. (Adaptive capability). An organization's adaptive capability at a time point is the maximal speed at which it is able to change its offer portfolio.

Adaptive capability, that is the maximal speed at which an organization is able to change, might be different from the observable speed of change. This is because an organization might change at a lower speed than it could. For example, managers may not be willing to reconfigure offer portfolios because of low competitive pressure. We argue that in a competitive environment, the observable speed of change is a good approximation of the unobservable maximal speed (Le Mens, Hannan and Pólos, 2015b). Researchers contend that intense competitive pressure causes organizations to move faster in changing offer portfolios, accelerating innovation efforts, shifting market position

and rearranging network ties (Barnett and Carroll, 1995; Delacroix and Swaminathan, 1991; Dobrev, Kim and Hannan, 2001; Kim, Oh and Swaminathan, 2006; Stuart, 1999). In a Red Queen competition, where organizations are locked in a relentless race of self-reinforcing learning and adaptation, organizations must run at top speed to keep pace with competitors (Barnett, 2016; Barnett and Hansen, 1996). Practitioners report similar effects of competition on adaptation. According to General Motors' legendary CEO Alfred Sloan (1990, p. 277), car producers quickened the speed of model change under intensifying competition in the 1950s, moving from a 5-year circle to the now standard annual model change.

Definition 2.2. (*Competitive environment*). An organization's environment is competitive if its speed of portfolio change is the highest that the adaptive capability allows.

Under the condition of competitive environment, the elusive adaptive capability can be approximated with the observable speed of actual change. We defined the latter as:

Definition 2.3. (Speed of change). The (actual) speed of change in an organization's offer portfolio at a time point is the ratio of the distance between the portfolios and the length of the time interval.

Consider the example from the UK motorcycle market in Appendix A, where categories are called styles such as scooter, custom, supersport, sport/touring and trail/enduro. Imagine a motorcycle firm in 1995 has an offer portfolio consisting of scooter, custom and supersport. In 1997 it changes to scooter, sport/touring and trail/enduro. The annual speed of change is the distance between the two offer portfolios divided by the length of the time interval (2 years in this example).

How do we measure the distance between two portfolios across different categories? This question lies at the heart of the difficulties in conceptualizing the content of change. Greve (2011, p. 107) describes this problem in the context of the ship market:

... some ship types are especially distinct on certain dimensions, such as the greater concern for safety in the design and operations of passenger ships than in cargo ships, but measuring and integrating such distinctiveness poses a challenge... Design and validation of a difference scale between pairs of ship types would thus be difficult.

We address this problem by drawing from cognitive psychology and the literature on categories. We propose the following procedure that measures distance between a producer's offer portfolios at different time points in a multidimensional offer space: (1) measuring perceived similarity between pairs of categories; (2) converting perceived similarity to cognitive distance between pairs of categories from the 'universal law of generalization' (Shepard, 1987); (3) measuring cognitive distances between sets (i.e. portfolios) of categories an organization covers at different points in time with the Hausdorff distance (Burago, Burago and Ivanov, 2001; Goldberg, Hannan and Kovács, 2016).

We explain the procedure using the example given in Appendix A. First, the perceived similarity between pairs of categories can be measured by surveying users, consumers, enthusiasts or experts. Like the ship categories, some motorcycle styles are similar while others are distinct from each other. For instance, the supersport style is considered very similar to the sport/touring style but totally different from the scooter style. As a result, people may assign a higher similarity score between supersport and sport/touring than between supersport and scooter.

Second, we convert the pairwise similarity scores into a measure of cognitive distance between category pairs. This is done by inverting Shepard's law, which states that the perceived similarity between a pair of stimuli is a negative exponential function of the distance between their mental representations (Shepard, 1987). The higher similarity score between supersport and sport/touring will convert into a shorter cognitive distance, reflecting the intuition that objects perceived as similar are located closely in our mental space.

Finally, we take account of the possibility that organizations offer products/services in more than one category. While Harley-Davidson engages almost exclusively with the custom style, with its distinctive offer of choppers, Honda spreads its offer across multiple motorcycle styles. In other words, we need to measure the distance between portfolios (or sets) of market categories, given the pairwise distance between categories from step two. In the case of our hypothetical producer, we want to measure the distance between its 1995 portfolio consisting of scooter, custom and supersport and its 1997 portfolio consisting of scooter, sport/touring and trail/enduro.

A widely used distance measure between subsets of a metric space is the Hausdorff distance, defined as the maximal of the shortest pairwise distance between the elements (e.g. motorcycle styles) of the two subsets (e.g. portfolios of motorcycle styles). We explain this in detail later with an empirical illustration (see An empirical illustration: data and methods). Note that in the simpler case of a specialist producer with only one category at a time, the Hausdorff distance (a measure of distance between two sets) collapses into the Euclidean distance (a measure of distance between two points). The Hausdorff distance can also handle cases of a single-category producer transferring to a multi-category producer and vice versa. Because of its flexibility and suitability for studying categories, the Hausdorff distance has become a widely used measure in category research (e.g. Conradie et al., 2017; Goldberg, Hannan and Kovács, 2016; Hannan et al., 2019).

Adaptive capability at the organization-market interface

In the previous section, we addressed the methodological challenge of conceptualizing the content of change by proposing a (cognitive) distancebased approach. Our approach also yields a precise definition of adaptive capability and identifies a condition under which it can be approximated with the observable speed of change. In this section, we address the theoretical gap in understanding how organization-market interface ties affect an organization's ability to adapt. We first review the existing research on the evolution of adaptive capability.

Existing research

Many studies have sought to understand how organizational adaptive capability evolves over time. Research in organizational ecology represents perhaps the most systematic endeavour, which centres on topics like age dependence (Carroll and Hannan, 2000; Hannan, 1998; Hannan and Freeman, 1984) and structural inertia (i.e. the logical converse of adaptive capability). Age dependence research concerns the relation between organizational age and the hazard of mortality. Structural inertia plays a central role in both dominating forms of age dependence: liabilities of newness and liabilities of obsolescence.²

A liability of newness means that mortality hazard falls with organizational age (Stinchcombe, 1965). Young organizations lack reliability and accountability because organizational structures are not institutionalized and routines are yet to be established. Because selection favours organizations with higher reliability and accountability, which improve as the organization matures (Hannan and Freeman, 1984), young organizations should experience a higher mortality hazard. However, it has become recognized that early studies supporting liability of newness (for a review, see Singh and Lumsden, 1990) failed to consider the effect of size (Barron, West and Hannan, 1994; Hannan, 1998). Because size tends to grow as the organization ages and because size buffers the organization from selection pressure, earlier findings of liabilities of newness appear to be largely due to liabilities of smallness.

A liability of obsolescence means that the mortality hazard rises with age (Barron, West and Hannan, 1994; Le Mens, Hannan and Pólos, 2015a; Sørensen and Stuart, 2000). Progressing institutionalization and growing cultural resistance to change prevent aging organizations from adapting to a changing environment, that has drifted away from the environment in which it was founded and with which it was closely aligned.

Our model differs from the previous research in two ways. First, what unites the majority of existing studies both within organizational ecology and beyond is their focus on the internal forces of adaptive capability, reflected in their using organizational age as the internal clock of institutionalization (for a review, see Bakker and Josefy, 2018). In contrast, we model the overlooked but acutely relevant external forces, utilizing *market tenure* to track institutionalization process at the organization–market interface. 'The external pressure towards inertia seem[s] to be at least as strong'

²There are also liabilities of adolescence that predict an initial rise and a subsequent fall of mortality hazard with age (Brüderl and Schüssler, 1990). We do not include them here because: (1) their argument does not relate to adaptive capability, but relies on how endowments evolve with organizational age; (2) they have received limited empirical support.

(Hannan and Freeman, 1977, p. 932) as the wellstudied internal forces, because 'it takes time for organizations to develop enduring exchange relations with key actors in the environment' (Hannan and Freeman, 1984, p. 160).

Second, most previous studies focused on outcomes like mortality hazard, performance or innovation, while our model looks at the evolution of adaptive capability per se. In spite of its importance, adaptive capability has largely escaped precise definition and theoretical modelling. Instead, it has been vaguely mixed with other mechanisms such as endowments, position and imprinting to yield predictions of organizational outcomes that often conflict with each other (Hannan, 1998; Le Mens, Hannan and Pólos, 2011, 2015a). Focusing on adaptive capability is not only necessary to better understand this central concept, but also a potential stepping-stone towards teasing out the conflicting findings.

Segment-level institutionalization

An organization's offer portfolio might concentrate on one category or be spread across multiple categories. Here we model the more complicated case of an organization engaging with multiple categories. In the simpler case of an organization serving a single category at a time, the underlying institutionalization process and its effects on adaptive capability resemble those in the multi-category model.

Because offers in different market categories appeal to distinct audience segments, an organization's allocation of engagement resources by market categories divides engagement by audience segments. We argue that the tastes for products and preferences for engagement practices of the audience members within the same segment are similar to each other, but differ from those of the other audience segments. Audience members who are similar (e.g. in terms of age, gender, education background and income) tend to have close social ties and possess similar tastes (McPherson, 2004). They are more likely to form a homogeneous community to which products of the same market category and similar sets of engagement practices are appealing.

In contrast, audience members who are dissimilar to each other tend to have fewer social ties and tend to possess dissimilar tastes. They are also less likely to find products of the same category and similar sets of engagement practices appealing. For example, people who ride a Harley-Davidson chopper (i.e. custom style) are more similar to each other in terms of socio-economic background and tastes than to those who ride a Vespa (i.e. scooter style). Motorcycle producers use very different practices to engage with and appeal to riders of custom style and scooter style. Because of the distinct tastes and engagement practices across segments, we start to model institutionalization at the segment level before moving to the (aggregated) market level.

We present a recursive argument in the form of a reinforcing feedback loop (see Figure 1). The plus sign inside an arrow means that the two variables linked by the arrow move in the same direction (i.e. if A increases, B increases), while the minus sign indicates that the two variables move in opposite directions (i.e. if A increases, B decreases). As an organization's segment tenure (i.e. the time passed since the organization enters a market segment) increases, the length of engagement with segment audience also increases. Engagement refers to organizational activities at the organization-market interface, such as: (1) learning about the idiosyncrasies of the audience segment and its aesthetics; (2) designing or redesigning features appealing to the target audience; and (3) trying to establish a favourable identity in the target audience segment (Hannan, Pólos and Carroll, 2007).

Honda's experience in entering the US market (Pascale, 1984) vividly illustrates the learning and engagement process. When Honda entered the US motorcycle market in 1959, it targeted the traditional 'black leather jacket' segment (e.g. riders of Harley-Davidson choppers), whose love for large bikes defined the motorcycle market. The two Honda executives arrived in the USA with an inventory heavily weighted towards larger motorcycles. Soon they learned hard lessons about the idiosyncrasies of local conditions and customer preferences. The large 250cc and 305cc Honda bikes were leaking oil and encountering clutch failures because motorcycles in the USA are driven much farther and much faster than in Japan. While the Honda lab in Japan redesigned the head gasket and clutch spring to adjust to the local idiosyncrasies, another surprise struck the Honda US team. The lightweight 50cc Honda Supercub (i.e. scooter style) has been embraced enthusiastically by a new customer segment - average Americans. Gradually, Honda learned appropriate ways to engage



Figure 1. Segment-level institutionalization of the organization-market interface [Colour figure can be viewed at wileyonlinelibrary.com]

with this largely untapped segment by adjusting its distribution channel and marketing campaign.

The emergent nature of Honda's learning experience illustrates that learning is cumulative (Mintzberg and McHugh, 1985). During this cumulative process, individuals specializing in a segment develop their knowledge of audience preferences and skills of serving the segment only incrementally. An organization's knowledge of and skills to appeal to the idiosyncratic tastes of an audience segment are built up over many practiced trials (Bouguerra et al., 2020; Cohen and Levinthal, 1990). As an organization learns to engage with its audience, technical solutions and communication patterns are repeated and finetuned. With increasing length of engagement ties, engagement patterns are accumulated and maintained within routines (routinization of segment engagement pattern). Organizational routines are repetitive and recognizable patterns of interdependent actions, involving multiple actors (Cyert and March, 1963; Feldman and Pentland, 2003; Nelson and Winter, 1982). For example, Honda's 'You meet the nicest people on a Honda' ad campaign, repeated in slightly varying versions in mainstream magazines like Life, Look and The Saturday Evening Post in the 1960s and 1970s (Rothfeder, 2014), became a central engagement routine.

The longer a routine (including patterns of engagement) is in place, the more it gets *infused with value* (Selznick, 1957, p. 17). As engagement patterns are repeated and refined over time, relevant individuals at the organization–market interface (both organizational personnel and audience members) become habituated to and identified with existing ways of interacting with each other. That is, routinization brings about *taken-for-grantedness of segment engagement pattern*. For example, sport fans expect sportswear producers' sponsorship in major events targeting different segments like the FIFA World Cup, Wimbledon tennis tournament and American football Super Bowl. Accordingly, organizational members at the interface expect to set up budget and organize projects around the routinized engagement patterns.

To satisfy the increasingly taken-for-granted expectation that the engagement pattern will be repeated, an organization develops further routines (Kaufmann and van Witteloostuijn, 2018) that reinforce the persistence of segment engagement pattern. With rising persistence of routines, more idiosyncratic resources are developed to tailor to the tastes of the segment audience. Researchers found that as the tenure of a research and development (R&D) project group increases, members develop an idiosyncratic language and specialized coding scheme that impede communication with other groups (Katz and Allen, 1982). Linking both ends of the causal chain in Figure 1, we conclude that *idiosyncrasy* of segment engagement resources increases with segment tenure.

Market-level institutionalization

We now move to the market level (Figure 2), at which adaptive capability is defined. When an organization first enters a market, the length of engagement is zero for every segment. At the end of the first year, unless all the market categories in



Figure 2. Market-level institutionalization of the organization-market interface [Colour figure can be viewed at wileyonlinelibrary.com]

its portfolio have been updated, the average segment tenure is higher than at the time of entry. That is, the longer an organization's *market tenure*, the longer its *average segment tenure*.³ We have argued that resource idiosyncrasy within each segment increases with growing segment tenure. With rising average tenure across an organization's audience segments, the overall *idiosyncrasy of engagement resources* also increases.

Idiosyncrasy of resources means that their nature is specific to the structural and sociodemographic characteristics of the audience segment. Since audience segments across market categories have dissimilar tastes, the resources tailored for engaging with a particular audience segment become less transferrable for engaging with other audience segments (transferability of engagement resources). In his study on eight newspapers' adaptations to online media, Gilbert (2005) reported that the sales reps specializing in selling to print advertisers have great difficulties targeting online advertisers because their knowledge and routines were tailored to the print segment. This is hardly surprising, given the cumulative nature of learning for both individuals and organizations (Cohen and Levinthal, 1990).

As transferability of resources diminishes, it takes longer to mobilize resources to engage with a new segment and to change offer portfolios. Because an organization's total amount of resources is finite, organizations (especially mature ones) often have to reallocate existing resources to engage with a new audience segment. When studying firms from seven industries experiencing technological shifts, Cooper and Schendel (1976) found that most incumbents diverted resources to enter new segments. Even if an organization can obtain extra resources, it still faces challenges and delays in integrating them into the existing structure (Cohen and Levinthal, 1990).

The less transferable are the engagement resources, the lower is the speed of reallocating resources. Gilbert (2005) found online business proposals often stalled over 2 years in print newspaper organizations due to low transferability of resources (e.g. skills of sales reps and editors) to the online segment. The slow adaptation was prevalent across the newspaper organizations, even when the urgency of change was recognized and money was provided. Lower speed of reallocating resources in turn increases the stability of the offer portfolio. This again raises the length of engagement ties with existing audience segments, because the current product categories stay longer in the portfolio. The speed of reallocating resources slows down further as lengthening ties reinforce engagement routines. As such 'repetitive modes of responding to external pressures crystalize into definite patterns' (Selznick, 1957, p. 16) with rising market tenure, spontaneous institutionalization of organization-market ties leads to decreasing adaptive capability (i.e. speed of changing offer portfolios):

³Organizations may drop segments which are not successful, thus changing their average segment tenure. In the absence of a generally agreed theory for predicting which segments will be successful (or unsuccessful), we resort to the simple assumption that it is randomly distributed. This assumption allows us to state that average segment tenure increases with market tenure.



Figure 3. Evolution of motorcycle style categories (based on MCIA new vehicle registration statistics and information provided by Nick Brown, formerly MCIA Statistics Department) [Colour figure can be viewed at wileyonlinelibrary.com]

Proposition: An organization's speed of changing its offer portfolios decreases with rising market tenure.

An empirical illustration: data and methods

Research site

We present an analysis of the product portfolio of motorcycle producers in the UK market. In line with our study's focus on methodology and theory, we intend this analysis primarily as an illustration that empirical estimation building on our proposed measure and theoretical model can yield sensible patterns.

The UK motorcycle market is a suitable empirical site because it satisfies the conditions of our theoretical model. First, the period we study is characterized by intense market competition (Definition 2.2), under which the actual speed of change is a good approximation of adaptive capability because the producers are more likely to move at their top speed. Our data starts from 1976 when the MCIA (Motor Cycle Industry Association of the UK) started to assign models to different styles. This was a period of intensifying market competition, when Japanese producers' domination was eroded by fierce attacks from continental European and Chinese competitors (Waterer and Nicholls, 2015). In 2013, brands from Europe (35%) and China (12%) together held almost 50% of the market.

Second, motorcycle producers often use distinct engagement practices for different audience segments. Industrial insiders agree that selling different motorcycle styles is about selling different dreams to various customer groups with distinct tastes (Nicholls, 2018; Thomas, 2015). To engage with customers of the adventure style, BMW established a training school headed by the rider Simon Pavey – a legend for the target audience segment (BMW, 2017). To reach out to the scooter customers who are often busy commuters in a metropolis, BMW has been sponsoring the London Marathon with a fleet of scooters operating alongside the runners (BMW, 2015).

Figure 3 shows the evolution of the 20 styles used by MCIA to categorize motorcycles between

1976 and 2013.⁴ We also attach the MCIA definitions for the eight contemporary styles (since 2000) and their respective best-selling model in 2014 (see Appendix A). The MCIA style system is the guiding category system in the UK motorcycle market because it serves as an important guide for producers, dealers and consumers (Nicholls, 2018).

Data and methods

The original data set provided by Data source. the MCIA covers all new motorcycle registrations in the UK from 1976 to 2013. It contains annual information on the names of the producer and model, country of origin,⁵ engine capacity, style and the number of registrations of that model. We selected the final sample according to the following criteria. First, firms should have a sizable presence in the UK market (i.e. with annual sales of at least 20 styles of motorcycles in two consecutive years). If a producer sells too few motorcycles, we believe the institutionalization process in our model may not take place because a producer's engagement with the UK audience is negligible. Second, we only included those producers whose year of UK market entry is known, so that we can accurately calculate market tenure.

The resulting data set is an unbalanced panel with 90 producers, of which only eight are UK producers. This is not surprising, since the UK motorcycle industry collapsed in the early 1970s under the Japanese whirlwind (Koerner, 2012). Twenty-four producers are headquartered in Europe, North America and Japan. The other 58 producers are from the rest of the world, including 42 Chinese producers who entered after China joined the World Trade Organization in 2001.

It might seem natural to measure the distances between product portfolios with the commonly used technical features like engine size (e.g. Wezel, 2005; Wezel and van Witteloostuijn, 2006), number of strokes, engine type, etc. Yet, how a motorcycle is perceived by its audiences is determined not only by technical features, but also by non-technical ones like the position of handlebars, seat height, size and form of windscreen,

⁴According to the MCIA (2015), a motorcycle is a motorized two-wheeled vehicle with an engine capacity over 50cc and speed capability over 30 mph, whose riders must be 17 years or over. ⁵Manufacturer country, not assembly country.

amount of chrome content and fairing (a shell intended to reduce aerodynamic drag). For example, the BMW 1300 GT is categorized as a touring bike, while the BMW 1300 S as a supersport bike. Both are almost identical in terms of 'hard' technical features. But they clearly satisfy different user purposes and target distinct customer segments, which are defined mostly through their design features. A touring bike needs to have a larger windscreen, upright sitting position and luggagecarrying capacity to suit long-distance travel, while a supersport bike has a smaller windscreen, forward sitting position and aerodynamic fairing to reduce air resistance and maximize speed. Thus, we code the changes of product portfolios in terms of MCIA style assignments, which consider a broad mix of technical and non-technical features.

To determine the distances between the 20 styles, we interviewed three industrial experts and asked them to assign similarity scores to all pairs of styles. We constructed a matrix of similarity scores between styles using the reports of the respondent with the most experience with market audiences. Then, we rescaled these similarities to yield a distance metric through a reverse application of the negative exponential relationship between similarity and distance (Shepard, 1987).⁶

Measurement

Dependent variable. In this section we illustrate how to calculate the speed of movement across styles using our (cognitive) distance-based measure. Calculating speed requires a specification of time and distance. We use the Hausdorff distance (Burago, Burago and Ivanov, 2001), probably the most widely used measure of distance between sets, to measure the distance between portfolios of motorcycle styles. It calculates the distance between two sets as the maximal of the shortest pairwise distance between the elements (i.e. styles) in the two sets (Figure 4). Let h(A, B) = max(min(d(a, B))) be the maximum a∈A within the set A of the minimum (point-to-set) distances to B. A point-to-set distance is the minimum over the distances from the point to the elements of the set. The standard Hausdorff distance is

$$H(A, B) = \max(h(A, B), h(B, A)).$$
 (1)

⁶We set the scaling parameter in Shepard's formula to one.



Figure 4. Illustration of the calculation of Hausdorff distance (see text for explanation) [Colour figure can be viewed at wileyonlinelibrary.com]

The Hausdorff distance is set by the mostdistant pair of elements in the two sets, without taking other (closer) elements into account. Because audience perceptions might be affected by the other elements in the sets, we also use a variant of the Hausdorff measure, first introduced in Dubuisson and Jain (1994). Instead of taking the maximum of the shortest distances, the modified Hausdorff distance calculates the average of the distances between all the elements of one set and the closest element in the other set; and it defines the distance between a pair of sets as the maximum of these two averages. Let h'(A, B) = $\frac{1}{|A|}\sum_{a\in A} \min(d(a, B))$, the average within the set A of the minimum (point-to-set) distances to B. The modified Hausdorff 'distance' we use (there are many) is

$$H'(A, B) = max(h'(A, B), h'(B, A)).$$
 (2)

In order to measure a producer's speed of changing its offer portfolio, we transfer the original data at the model level to the producer level. This is done by constructing a producer's offer portfolio across motorcycle styles for each year. If a producer has eight models spread over three styles in a year, its offer portfolio in that year is coded as consisting of the three styles. Suppose that in the subsequent year, the producer adds five models – three from its existing styles and two from a new one.⁷ We code the style portfolio in the latter year as the existing three styles plus the new one. Then we calculate the Hausdorff distance between the style portfolios at the two time points. For this we use the pairwise cognitive distance between the styles transferred from the similarity scores of an expert, by relying on the universal law of generalization (Shepard, 1987). We compute both the Hausdorff distance and the modified version to ensure the robustness of our results.

To calculate the speed of change, we divide the distance by the length of time used for covering the distance. Our data contains the producer's offer portfolio in December of each year, therefore the time length between two observed portfolios is 1 year. We calculate the (annual) speed of portfolio change by dividing the Hausdorff distance by one, because our data is annual. When researchers have data of a different frequency (e.g. every 2 years), they need to consider it when calculating annual speed (e.g. dividing the distance by two).

Independent variable. Our independent variable is the tenure of a producer in the UK market. This is not equivalent to the organizational age, because many foreign firms had been in business before entering the UK. We argued above that market tenure is more appropriate for testing the effect of institutionalization at the organization-market interface than the age of the parent organization. Similar to Honda's US entry, when an established foreign producer enters the UK market, it needs to establish local ties, learn the UK audience tastes and adjust its offers accordingly. A foreign producer might be founded many decades ago (when the age clock starts), but it is a newcomer when it enters the UK market (when the market tenure clock starts).

Control variables. Because of the confounding effects of time and size (Barron, West and Hannan, 1994), we controlled for organizational *size*, which is measured as the producer's total number of motorcycles sold (registered) in a year. We also controlled for *style niche width* using the total number of styles a producer covers in a year, following the convention in existing studies (Vermeulen and

⁷We account for re-entries at the style level. If a style does not sell for at least two consecutive years, we consider the producer as having exited from this style. When the producer starts to sell the style again, we regard it as a re-entry into the focal style. In both cases, we code a respective change in its product portfolio.

Variable	Obs	Mean	SD	Min	Max	1	2	3	4	5	6	7	8
1. Speed	699	1.16	4.39	0	20.72	1.00							
2. Tenure	699	11.25	12.56	0	52	-0.15	1.00						
3. Tenure ² (000s)	699	0.28	0.55	0	2.70	-0.11	0.96	1.00					
4. No. models (000s)	699	0.02	0.03	0.001	0.12	-0.14	0.84	0.79	1.00				
5. Size (0000s)	699	0.45	1.09	0.002	10.03	-0.10	0.51	0.42	0.62	1.00			
6. Style niche width	699	3.41	2.32	1	8	-0.12	0.77	0.72	0.82	0.52	1.00		
7. Year $= 1994$	699	0.01	0.11	0	1	0.00	0.04	0.03	0.02	-0.01	0.06	1.00	
8. Year = 2000	699	0.03	0.17	0	1	0.00	-0.01	0.00	-0.03	0.00	-0.01	-0.02	1.00

Table 1. Summary statistics and bivariate correlations

Barkema, 2002; Wezel and van Witteloostuijn, 2006). In doing so, we build on prior research that has accumulated a body of evidence about the effect of number of niches on organizational change (e.g. Delacroix and Swaminathan, 1991; Dobrev, Kim and Carroll, 2003; Dobrev, Kim and Hannan, 2001). In addition, we controlled for the producer's total *number of models*. Because the effect of tenure on speed might not be linear (Le Mens, Hannan and Pólos, 2015b), we added the square term of tenure (tenure²). We also added dummies for 1994 and 2000, when the style system experienced large changes. All independent variables were lagged by 1 year. Table 1 presents the descriptive statistics and bivariate correlations.

Results

We adopt a conservative approach by fitting producer fixed effect models using ordinary least squares (OLS) regression, using only *within-firm* variation in tenure and speed. This approach deals with the unobserved heterogeneity that results from unmeasured stable differences among observationally equivalent firms that might affect the speed of portfolio changes.

Table 2 reports the results, measured in the standard Hausdorff distance (column 1) and modified Hausdorff distance (column 2). A producer's speed of change in style portfolios declines with market tenure for both distance measures. Therefore, the results support our proposition that adaptive capability decreases with market tenure.

The effects of the control variables also align with our expectations. A producer's speed of change declines with its size. As an organization grows larger and more complex, it faces stronger inertial pressure (Hannan and Freeman, 1984). Note that the size argument does not address the effect of time per se, although organizations tend to grow larger over time (Hannan *et al.*, 1998). In addition, style niche width negatively affects speed, albeit only significantly for the modified Hausdorff measure.

Although the results support our proposition, we need to address the potential confounding effects of age and tenure. Theoretically, the processes of institutionalization within the organization (following an age clock) and at the organizationmarket interface (following a tenure clock) are driven by different mechanisms. Empirically, it is very difficult to distinguish them because the age clock and the tenure clock tick simultaneously. As a result of the perfect correlation between age and tenure, age will be automatically dropped in a regression model including tenure and producer fixed effects. Nevertheless, we make an attempt to tease them apart.

Our approach is based on the assumption that the speed of institutionalization (both within the organization and at the interface) is presumably nonlinear – fast during the early period after organizational founding or market entry, then slowing down in later periods. Directly following founding or entry, institutionalization proceeds at a very high speed when relations of trust among strangers get established, new roles are invented, market ties are enacted and routines are set up (Stinchcombe, 1965). Like organizational memory, the stock of institutionalized features and ties grows rapidly initially. Its growth rate then slows down when the majority of new roles are defined, the bulk of procedures are standardized and most ties are established. This aligns with the cumulative nature of organizational learning (Cohen and Levinthal, 1990; Levitt and March, 1988). To summarize, we assume that both clocks for institutionalization within the organization and at the organizationmarket interface tick at a high speed shortly Table 2. Effect of tenure on speed of movement in product space with speed calculated in both standard Hausdorff distance (HD) and modified Hausdorff distance (MHD)

	HD	MHD	Age at entry (MHD)		
	(1)	(2)	(3) Age < 10	(4) Age ≥ 10	
Tenure	-0.16**	-0.068**	-0.18*	-0.062*	
	(0.076)	(0.029)	(0.089)	(0.037)	
Tenure ² (000s)	2.55**	1.14**	7.82**	1.02*	
	(1.11)	(0.44)	(3.26)	(0.55)	
Size (0000s)	-0.46**	-0.17**	-2.27	-0.13*	
	(0.20)	(0.081)	(3.33)	(0.076)	
Style niche width	-0.66	-0.33**	-0.84**	-0.22	
	(0.43)	(0.15)	(0.41)	(0.16)	
No. models (000s)	-4.08	1.08	40.8	0.084	
	(6.69)	(2.35)	(37.7)	(2.37)	
Year = 1994	0.15	0.090	-0.90***	0.27	
	(0.65)	(0.24)	(0.17)	(0.20)	
Year = 2000	0.028	0.12	-1.16**	0.40	
	(0.96)	(0.47)	(0.51)	(0.57)	
Constant	4.73***	2.03***	2.72***	1.78***	
	(1.28)	(0.48)	(0.86)	(0.61)	
No. observations	699	699	187	512	
\mathbb{R}^2	0.037	0.046	0.157	0.029	

OLS estimates with producer fixed effects.

Standard errors in parentheses.

P · · · · · ·

after founding or market entry, then at a slower pace.

If the speed of institutionalization decreases with age and market tenure, we expect different patterns of adaptive capability between an old organization and a young one that enter a market at the same time. When an old organization enters a new market, its internal institutionalization clock ticks slowly while its interface institutionalization clock ticks fast. Thus, the decline of its adaptive capability should be modest because it is largely due to external institutionalization. For the young organization, both clocks for internal and interface institutionalization tick fast. Its adaptive capability should experience a more dramatic decline since both institutionalization processes advance rapidly. In this way, we can partially tease out the effect of institutionalization at the interface (following the tenure clock) from that of internal institutionalization (following the age clock).

In doing so, we split our data into two subsamples of: (1) producers that entered the UK market at a young age; and (2) producers that entered the UK market at an older age. The results of the split samples are reported in models 3 and 4 in Table 2. Model 3 is based on the sub-sample consisting of younger organizations (aged between 0 and 9 years at entry), while model 4 is based on the sub-sample including the older organizations (aged above 9 years at entry). As expected, tenure (which in fact also includes the age clock) has a much greater negative effect on the adaptive capabilities of young organizations, whose age and tenure clock both tick fast. The absolute value of the effect for the young organizations (model 3) is almost three times as large as that for the older organizations (model 4), whose age clock already slowed down. We experimented with different breakpoints for the two sub-samples and found the converging pattern for other choices. But we get the sharpest distinction with age 10 as the breakpoint.

To further ensure the robustness of our results, we carried out additional analyses that address the potential selectivity issue. By employing the Heckman two-step selection procedure, we have obtained results (see Appendix B) similar to Table 2.

^{*}p < 0.1.

^{**}p < 0.05. ***p < 0.01.

Discussion

Contributions to research on organizational adaptation

Our paper makes both methodological and theoretical contributions to the research on organizational adaptation. While both process and content are important for understanding organizational change, existing measures have been weak in conceptualizing the content of change with a solid theoretical grounding (Carroll and Hannan, 2000). Our measure addresses the drawbacks of the existing measures that ignore distinctions in content of change and differences across market categories (Greve, 2011). Portraying adaptation as an organization's movement in a multidimensional space of categories (Le Mens, Hannan and Pólos, 2015b; Liu and van Witteloostuijn, 2020), our measure is grounded in the recent socio-cognitive turn of organization theory granting a central role to categories (Hannan, Pólos and Carroll, 2007; Hannan et al., 2019; Zuckerman, 1999). With minor adjustments, our measure can be adapted to conceptualize strategic reorientation, innovation activities, mergers and acquisitions, and internationalization.

Building on the methodological development, our theoretical model addresses the gap between the increasing dependence of organizations on market audiences and the dearth of research on how organization-market ties affect adaptive capability. Our outward-looking model moves research beyond its current focus on internal forces, thus contributing to a more complete understanding of adaptive capability. Our study also provides a definition of adaptive capability, an important concept that has so far escaped precise definition. Furthermore, we identify a condition (i.e. competitive market) under which the elusive concept can be observed and operationalized.

Connections to research on product life cycle and technological change

Our model provides additional support for two widely recognized industry-level regularities in product life cycle (PLC) and technological change research (e.g. Anderson and Zeithaml, 1984; Cohen and Klepper, 1992; Utterback and Abernathy, 1975): (1) over time, incumbents devote increasing efforts to incremental process innovation; (2) new entrants account for a disproportionate share of radical product innovation in the industry (de Bresson and Townsend, 1981; Klepper, 1996). A dominant explanation relies on economic rationality coupled with size assumptions (Cohen and Klepper, 1996; Galende and de la Fuente, 2003; Klepper, 1996). Because returns to process innovation increase with firm size, incumbents (assumed of larger size) focus on incremental process innovation to benefit from their size advantages. New entrants (assumed of smaller size) are endowed with greater innovativeness in order to overcome the selection pressure dictated by economies of size in R&D.

Our study answers to Klepper's (1996, p. 579) call for additional support for the two pivotal regularities: 'the extent of the support... depends on the degree to which these same patterns can be explained by other theories'. Our model relies on an institutionalization process that varies only with market tenure and works without size assumptions. Recent entrants with shorter market tenure have less institutionalized organization–market interface and enjoy greater adaptive capability. They thus move at higher speed, carrying out radical product innovation that covers longer distance. Incumbents, whose ability to reallocate resources becomes constrained with rising tenure, instead focus on process innovation that covers shorter distance.

Implications for practice

Our study has important implications for practitioners of organizational change, who have marvelled at the high failure rate of change initiatives (Beer, Eisenstat and Spector, 1990; Kotter, 1995). Managers often painstakingly set up detailed change plans at internal meetings and consultants are hired to run workshops for employees, as if change concerns only internal stakeholders (Hirschhorn, 2002; McKinsey, 2020). Our model suggests that such inward-looking practices overlook the external ties as an important obstacle of change. Instead, organizations should carefully consider the implications on established ties at the organization-market interface (or other kinds of external ties) and consult external stakeholders like key customers, distributors and suppliers. In setting up the change plan, it is important to include potential impacts on the expected reactions from external stakeholders, as well as ways of aligning steps of internal change with changes taking place at suppliers and distributors. Furthermore, organizations should pay special attention to frontline employees standing at the organization-market interface. Extensive consultations with experienced frontline employees may help to better foresee the challenges in managing external ties during change. Resources, training, smooth communication channel and timely support should be available for them to navigate conflicts between change initiatives and institutionalized engagement patterns.

Limitations and future research

This study has several limitations, which we see as fruitful avenues for future research. First, our empirical efforts to separate the effect of organizational age from that of market tenure are only partial, because of the perfect correlation between age and tenure with producer fixed effects. We believe this is a reasonable approach as an empirical illustration for our proposed measure and model. Future research could achieve a cleaner separation of the two effects by collecting data that measure the model variables linking market tenure and adaptive capability (see Figures 1 and 2). For example, data measuring the quantity and quality of interface ties – as well as idiosyncrasy of engagement resources - are valuable for directly testing the effect of institutionalization at the organization-market interface on adaptive capability.

Second, we focus on only one type of external ties, that is market ties with stakeholders like users and customers. However, an organization has other stakeholders such as regulators, investors and alliance partners (Baker and Faulkner, 2005). Future research may explore questions like: How do ties with other types of external stakeholders affect adaptive capability? Do other external ties conflict with or complement market ties in their effects on adaptive capability? How do varying attributes of ties, such as weak versus strong (Granovetter, 1977, 1985) and indirect versus direct (Bian, 1997; Singh, 2005), impact adaptive capability? Future research may explore these questions by building on our study and related studies investigating the effects of network structural attributes (e.g. Hughes et al., 2014; Kim, Oh and Swaminathan, 2006).

Third, future research may utilize our model to address some puzzling questions in research on modularity and platforms such as Netflix and Google's Android (e.g. Baldwin and Woodard, 2009; Gawer, 2009, 2014) concerning when, how and why third-party complementors⁸ support a platform (Eisenmann, Parker and Van Alstyne, 2006; Gawer, 2009; McIntyre and Srinivasan, 2017). Because switching to a new platform requires significant changes in routine for complementors, their organizational attributes and adaptive capabilities affect their support for an emerging platform (McIntyre and Srinivasan, 2017). Our model indicates that a complementor's market tenure and length of ties with existing platforms might negatively influence its ability to switch. Future research may investigate the effects of a complementor's market tenure and tie duration on its likelihood, timing and mode of switching to an alternative.

Finally, future research may explore how industry maturity affects the evolution of adaptive capability. Although our empirical illustration concerns a mature industry, we believe our basic model is applicable to younger industries like the renewable energy sector and on-demand video-streaming platforms. However, we expect pressure from the external environment to differ in younger industries. For example, institutional pressure on an organization to conform to traditions and customs (Kim, Oh and Swaminathan, 2006) may be lower in younger industries. This in turn may slow down institutionalization at the market-organization interface. It is our hope that future research will explore these exciting questions, exposing our model and measure to further tests and applications.

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⁸For example, suppliers of films and sitcoms streamed on Netflix, Android-compatible software and apps.

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Supporting Information

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Figure A.1: Honda CRF 250L, retail price new: from £3,914

Figure A.2: BMW R 1200 GS, retail price new: from £11,319

Figure A.3: BMW R 1200 RT, retail price new: from £11,279

Figure A.4: Kawasaki Z1000 SX, retail price new: from £8,999

Figure A.5: Yamaha YZF R125, retail price new: from £4,471

Figure A.6: Honda CBF 125 M, retail price new: from £2,075

Figure A.7: Harley-Davidson Sportster N 883, retail price new: from £5,844

Figure A.8: Honda PCX 125, retail price new: from £2,255

Table B.1: Effect of tenure on speed of movement in product space: estimates of a Heckman selection model

Supplementary Material

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