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HRM Algorithms: Moderating the Relationship between Chaotic Markets and Strategic Renewal

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HRM algorithms can profoundly impact organizations in the digital economy era. In the face of turbulent and complex market conditions, strategic renewal is regarded as one of the most important organizational mechanisms for dealing with market uncertainty and a turbulent environment. However, the existing research remains elusive about the relationship between market-level conditions and firm-level strategic renewal. Our paper addresses this important gap by examining the potential enhancement of agile strategic renewal in high-uncertainty environments through the implementation of HRM algorithms. Drawing on Chaos Theory, we argue that HRM algorithms have the potential to support the self-organization capacity of a workforce, supporting better alignment with changing environments. Using covariance-based structural equation modelling on a survey of over 500 Spanish firms, our findings provide partial support for the modelled hypotheses by showing that the use of HRM algorithms positively moderates the relationship between market turbulence and strategic renewal, but does not appear to moderate the relationship between market complexity and strategic renewal. The study contributes to our understanding of the importance of adopting internal business analytics systems to stimulate agility and align the workforce more effectively with changing environments, but also highlights their less substantive role in deciphering complex external factors.

Introduction

Conjectural shocks from major events such as the COVID pandemic (Liu and Lee, 2020) and the on-going conflicts in Eastern Europe and the Middle East (Loon, Otaye-Ebede and Stewart, 2020; Ratten, 2022), as well as more structural transitions, such as the digital, sustainable, responsible, and social transformations of industry (Jiang *et al.*, 2021; Sardana *et al.*, 2020; Wang *et al.*, 2022; Warner and Wäger, 2019), are leading to a 'new normal' for companies that is characterized by high uncertainty, ambiguity, upheavals, change and market complexity. However, the existing research fails to examine the extent to which macro-level factors might affect firm-level manifestations when dealing with a high degree of uncertainty and market complexity. This paper analyses whether the adoption in such contexts of internal business analytics, in particular HRM algorithms, facilitates more agile strategic renewal.

Organizations are increasingly part of complex adaptive systems that are composed of interlinked external, organizational and strategic forces that have a profound influence on their competitive performance (Schneider, Wickert and Marti, 2017). Such systems mean that change needs to be conceptualized as the norm against which to align policy and strategy (Levy, 1994), meaning that firms must be able to identify the underlying patterns that guide this complexity to make them the beacons around which the internal workforce will dynamically self-organize (Mason, 2007; Smith, 2001). This potentially generates better organic alignment with the dynamics of such a complex system and leads to more effective strategic renewal (Nguyen, Peltoniemi and Lamberg, 2022; Volberda, Baden-Fuller and van den Bosch, 2001). Such self-organization largely relies on the capacity of an organization's entire human resources to be flexible in their quest for synchrony with these underlying patterns (Brown and Eisenhardt, 1997;

Parker and Grote, 2022). This is said to be achieved in organizations when there are strong dynamic references around which collaborators adjust their work habits and decision-making in a self-referencing process (Black and Farias, 1997; Levy, 1994).

Digitally enabled HRM algorithms, which are decision-making systems based on machine-learning classifiers and advanced analytics (see Charlier and Kloppenburg, 2017 or Czarnowski and Pszczólkowski, 2020), have the potential to serve as powerful references within the self-organizing workforce because they provide the dynamic adaptive versatility that formal guidelines lack and also the mouldability that informal value-based references do not offer (Parker and Grote, 2022). For instance, the Lego Group introduced a system of HRM algorithms to achieve greater engagement with its workforce. This ensured that its employees' initiatives and ideas were properly integrated within organizational boundaries, leading to a better hands-off overview among senior managers (Minbaeva, 2018). As a result, the firm was able to self-organize in an agile manner around opportunities adapted to current digital disruptions in the entertainment industry—the root of the strategic renewal whereby Lego diversified into the implementation of augmented reality to improve its users' experience (Hinsch, Felix and Rauschnabel, 2020).

In this paper, we adopt this perspective, which is grounded in the Chaos Theory of strategy formulation, to better explain and model the impact of market turbulence and complexity on strategic renewal (Levy, 1994; Mason, 2007). From the perspective of strategic agility, we also assess whether the adoption of HRM algorithms by the organization helps to positively moderate these relationships (Ahammad, Glaister and Gomes, 2020; Junni *et al.*, 2015). We achieve this by using primary survey data on over 500 growth-oriented firms to test the theoretical predictions with a covariance-based structural equation model. While data collection during the fourth COVID wave provided the ideal uncertainty conditions to test the effect of turbulent, complex markets, the Spanish context offered an uncertainty-averse setting that is appropriate for analysis of the adoption of a decision-making technology, in this case, HRM algorithms. The results of the study mostly validate our model, with the nuance that HRM algorithms are found to have a positive moderating role on the relationship between external change and strategic renewal, but only in the case of market turbulence. No moderation was identified for market complexity.

The study makes several key theoretical and practical contributions. First, it recovers the principles of Chaos Theory, which have fallen somewhat out of favour in recent decades despite the increase in environmental complexity and uncertainty, as well as convulsive strategic contexts that generate the precise complex adaptive systems to which the theory is meant to be applied (Levy, 1994; Mason, 2007). Our findings therefore call for a major resurgence in the implementation of the premises of Chaos Theory in management research, where HRM algorithms can potentially enable the self-organization aspect of a theory that was previously considered ineffective from an organizational perspective in the case of corporate strategy formulation (Smith, 2001).

Second, the study contributes to the relevant academic literature by analysing HRM algorithms from a different angle from the predominant one in current research on the topic (Zhou *et al.*, 2021). While the current literature mainly addresses the debate from the micro or meso levels, our approach is novel in that it offers a macro perspective (Pereira *et al.*, 2023). Few studies have analysed, as this one does, the impact of the use of HRM algorithms on strategic performance in the wider economy (Cheng and Hackett, 2021), and even fewer have explored their role in strategic agility within complex adaptive systems. As such, our study highlights the potential role of HRM algorithms as the missing provider of the internal, dynamic reference around which self-organizing workforces can rapidly align in order to render the necessary agility for strategic renewal. Hence, HRM algorithms can be useful tools for fostering a more rapid strategic self-alignment of individual work habits and decision-making in synchrony with macro-environmental changes affecting the company.

A third important contribution of the study is that rather than promulgating the common fear that smart algorithms will impose compliance and take over decision-making in organizations (Bucher, Schou and Waldkirch, 2021; Kellogg, Valentine and Christin, 2020; Leicht-Deobald *et al.*, 2019; Parry and Strohmeier, 2014), our findings show that HRM algorithms, when used for strategic agility and alignment, can lead to new work designs that support greater self-organization of individual work habits and decision-making (Parker and Grote, 2022). Our study makes a case for the possible use of HRM algorithms to promote strategic agility and competitiveness, in stark contrast to their much-criticized association with conformity. It also suggests ways in which algorithms could support management on the edge of chaos in a state of continual strategic effervescence, offering a means for perpetual strategic alignment.

Theoretical development

Strategic renewal

Firms must satiate their drive for immediate value creation through the strategic exploitation of existing resource strengths and capabilities. This requires order, control and stability, as well as adaptation for

tomorrow based on explorative flexibility and creativity (March, 1991; Volberda, Baden-Fuller and van den Bosch, 2001). The need for such renewal seems evident in the current context of increased socio-economic change brought about by pressures from digital (Warner and Wäger, 2019), sustainable (Wang *et al.*, 2022), responsible (Sardana *et al.*, 2020),and social (Jiang *et al.*, 2021) transitions of markets and industry. However, many firms are still shifting their internal management away from exploratory strategic renewal (Liu *et al.*, 2022; Zhang *et al.*, 2020), often because they are dissuaded by its perceived links with organizational trauma and loss of profits (Nguyen, Peltoniemi and Lamberg, 2022).

All firms evolve to varying extents, but the issue in strategic renewal is whether they can change beyond the chosen strategic trajectory that they have embarked upon. Strategies are part of internal policy and structural inertia. Any such renewal entails breaking from the routines and institutionalized processes that human resource management often works hard to systematize and implement. Strategic renewal determines whether the firm can adopt an adaptive perspective to change that seeks to overcome such rigidities (Lewin and Volberda, 1999). Increased change is likely to put strain on the synchrony of many firms with their external environment, as their strategies diverge from external progress (Lewin, 1993). But the trade-off between perceptible short-term gains and uncertain long-term performance enhancement from strategic renewal is not always straightforward, even in the presence of external market pressures (Nguyen, Peltoniemi and Lamberg, 2022).

Chaos Theory

Strategy-making in a convoluted environment can be better approached and researched from a chaos viewpoint (Mason, 2007). The complex systems that connect a firm's external environment with its internal policy, and with its strategic trajectory, can appear to be bounded by completely random states of disorder and irregularity. However, all such systems have underlying patterns and deterministic laws (Lissack, 1997). '*Chaos theory suggests a need for a continuous strategy development process that involves all organizational members in the creation of a flexible, fluid plan'* (Bechtold, 1997, p. 195). From this perspective, the marketplace is viewed to be in a continuous state of disequilibrium, forcing firms to renew their strategic trajectories to better 'fit' the shifting market (Brown and Eisenhardt, 1997). Because of its transcendent non-linearity (Black and Farias, 1997), such change creates ripples in the market, leading to further disequilibrium and chaos for those left behind (Mason, 2007). As such, business environments are increasingly complex, adaptive systems, and a chaos perspective is required in order to better understand their turbulent dynamics and identify ways to deal with such settings (Brown and Eisenhardt, 1997; Levy, 1994).

The implication of the complex adaptive system perspective upheld by Chaos Theory is the acceptance that in order to cope with turbulent, complex environments, the system should be kept at the edge of chaos through self-organization (Frederick, 1998; Wilkinson and Young, 2002). When the system's parameters change, the process should spontaneously self-organize through the inter-relationships between its parts (Kazakov, Howick and Morton, 2021). Out of change comes opportunity and potential strategic advantage (Grant, 2016). Therefore, firms that can develop a synchronized self-organizing coexistence with their turbulent, complex environments stand to gain (Massari and Giannoccaro, 2021). Ideally, the complex adaptive system that balances a firm's external environment, its internal HR policy, and its strategic trajectory should be continuously reorganized into new patterns of relationships (Ahammad, Glaister and Gomes, 2020), from which renewed strategies will potentially emerge. The difficulty for managers arises when inertia together with internal HR and structural resistance make it harder for this adaptive system to take hold, thus preventing strategic renewal from occurring (Schneider, Wickert and Marti, 2017).

Firms faced with chaotic, turbulent, complex markets therefore need a strong capacity to adapt in order to facilitate strategic renewal. This includes the ability to review the organization dynamically in synchrony with the external business environment (Doz and Kosonen, 2010). Jamrog, Vickers and Bear (2006, p. 5) conceptualized strategic agility as the ability to move 'quickly, decisively, and effectively in anticipating, initiating and taking advantage of change'. A strategically agile firm is able to read turbulent and complex markets in order to adapt to and benefit from these external changes (Ahammad, Glaister and Gomes, 2020). In the increasingly complex global business environment, strategic agility is even more important if firms are to cope with uncertainty (Tarba *et al.*, 2023). Strategic agility in HRM depends on managerial capabilities and skills (Doz, 2020).

One of the reasons why firms frequently lack strategic agility is their inability to reorganize work in environments that are near the edge of chaos, and are hence changing continually and unpredictably (Ahammad, Glaister and Gomes, 2020). There is an incessant need for managers to obtain new information to understand the environment, and workers require strong references so that they can self-organize their work accordingly (Battistella and de Toni, 2018). The underlying deterministic laws guiding complex adaptive systems are rarely apparent to management. This limits their strate-

gic agility and consequently leads to inadequate internal HR policy to counter the pressure for strategic renewal. Moreover, employees who face environmental shocks are often restricted by rigid internal norms and structures (Glass, 1996).

Hypothesis building

Market turbulence and strategic renewal

Turbulence is defined as dynamism in the environment, involving rapid change in its sub-dimensions (Vorhies, 1998). Market turbulence puts pressure on the firm to be agile enough to keep up with or stay ahead of changes (Vaillant and Lafuente, 2019). Speed is a key factor for determining a firm's ability to align with a turbulent market. There are opportunities to be gained from turbulent environments, but only for those who can move quickly enough to take advantage of the window and avoid being left behind (Bustinza, Vendrell-Herrero and Gomes, 2019). Such agility and rapid renewal are the outcome of pre-emptive alignment, while purely reactive strategic adaptation is likely to leave a firm constantly trailing behind its ideal strategic edge-of-chaos frontier.

An increasing number of industries are facing turbulent environments. For example, the fashion industry, and its fast fashion segment in particular, is experiencing constant changes in consumer preferences, trends and global economic conditions that demand rapid strategic agility to remain competitive in a turbulent market. The post-COVID period has witnessed a rise in the number of eco- and ethically conscious consumers, which poses a challenge to many of the absolute low-cost foundational premises of fast fashion. Thus, for example, brands such as Nike have not sufficiently aligned with such change and faced dwindling sales and shareholder backlash in 2023 as a consequence of concerns surrounding ethical violations in its supply chain (Abdulla, 2023a). In contrast, one of the leading players in fast fashion, Inditex, enjoyed steady success over this same period, with an annual rise of 17.5% in its revenue and of 29% in earnings, mostly attributed to its strides in sustainability (Safaya, 2023). Inditex has been pro-active in steadily introducing sustainable measures to its production and brand collections as part of a profound strategic renewal of the group based on 'unique product propositioning, customer experience, sustainability, and the talent and commitment of our people' (Inditex CEO Óscar García Maceiras, cited in Abdulla, 2023b). Inditex's rival H&M is accused of using the term 'sustainability' as a mere checkbox exercise, rather than engaging in profound strategic renewal, and as a result has recently come under fire over what were deemed by Norway's consumer watchdog to be 'misleading environmental claims' (Abdulla, 2022).

The outcome of market turbulence is strategic obsolescence, where the key success factors for outcompeting rivals in a particular strategic group, or that are most valued by the targeted market segments, change. This leads to mismatched core competencies, the loss of competitive advantage (Grant, 2016), shorter decision windows and difficulties predicting customer, product and service requirements (Chakravarthy, 1997). Long-term control becomes impossible, and managers must engage in strategic renewal if they are to develop trajectories that are better aligned with operation in turbulent environments (Mason, 2007).

It is therefore hypothesized that:

H1: Market turbulence is positively associated with strategic renewal.

Market complexity and strategic renewal

Complexity is defined as the measure of heterogeneity and diversity in the environmental sub-factors that all simultaneously and interdependently affect the adaptive business system in which the firm operates (Mason, 2007). The multicollinearity of complex environments limits the firm's ability to understand and maintain an adequate strategic 'fit' with the external environment, which eventually has a negative effect on the effective implementation of the prevailing strategic trajectory. The use of information to plan and predict becomes more difficult (O'Reilly, 1982), management's ability to make sense of the firm's strategic position within its context is impaired (Black and Farias, 1997), and internal policy in response to the changing environment becomes more problematic (Lane and Maxfield, 1996).

For example, the markets for agricultural products are subject to complex, erratic fluctuations in supply and demand, geopolitical tensions, weather patterns and economic conditions, leading to highly volatile outputs, prices and conditions that impact businesses in related industries (Brea-Solís and Grifell-Tatjé, 2023). In the wine industry, firms that have maintained good strategic fit with complex markets by expanding to novel growing regions (e.g. the UK and Canada), innovating with new resistant grape varieties, implementing new technologies, and venturing into new product development options that were previously snubbed by the industry (non-alcoholic, vegan, bio, kosher wines, etc.) are experiencing more sustained growth (Gannon *et al.*, 2023; Meininge's International, 2024; Prakash, 2023). The Spanish wine producer Familia Torres was able to introduce a strong strategic focus on innovation without losing its heritage-based strengths and went on to achieve global sales of $265 million in 2022, being voted the 'World's Most Admired Wine Brand' by Drinks International as well as the 'Third Most Valuable Wine Brand' by the specialist wine magazine SOMM in January

2024 (Mackay, 2024). In an industry that often tends to be guided by legacy, Familia Torres has nevertheless employed strategic renewal to embark on a series of groundbreaking projects, such as organic viticulture and the founding of the International Wineries for Climate Action (IWCA) group. In contrast, wineries that have remained locked-in to tradition have lost their strategic fit owing to insufficient alignment with their increasingly complex external conditions, resulting in lost competitiveness (Summerfield, 2023; The Economist, 2019).

In order to recover strategic 'fit' in a complex external market environment, firms are likely to resort to strategic renewal. Rather than being increasingly disoriented through implementing their current strategy in such a complex environment, renewal by switching to a more 'fitting' trajectory can re-establish the strategic position of firms and better realign them with their circumstances.

As such, the following hypothesis is proposed:

H2: Market complexity is positively associated with strategic renewal.

The moderating role of HRM algorithms

Firms require the means to modify, influence and regulate their alignment with external change. Such skills depend to a large extent on their strategic capacity for quick organizational responses to environmental change (Jamrog, Vickers and Bear, 2006). However, because of the need to intricately and adequately interpret and understand the external environment, the development of the required agility to ensure strategic renewal is unlikely to be straightforward (Greenley and Oktemgil, 1997; Weber and Tarba, 2014).

Hence, companies require mechanisms that will properly stimulate and engrain that agility. Management algorithms can potentially serve this purpose by enhancing the speed and fit of alignment abilities (Zhou *et al.*, 2021). The greater a firm's strategic agility, the greater its capacity to align, and therefore the higher the level of market turbulence and market complexity that it can cope with (Chakravarthy, 1997; Doz and Kosonen, 2010).

However, agility within a complex adaptive system cannot be achieved by considering the environment and strategy alone; the organizational workforce must also simultaneously align with these factors (Ahammad, Glaister and Gomes, 2020). Strategic agility and alignment with a complex environment will be unlikely to succeed if organizational rigidities are not addressed (Jacobides and Billinger, 2006). To achieve the necessary organizational agility, managers are advised to generate internal HR momentum in order for their collaborators to 'self-organize' and thus keep up with the external changes and strategic renewal (Goodwin, 1999). Control from this perspective should be local, through a work design that offers reactive learning systems that instantly monitor environmental deviations, report problems or opportunities, and empower individuals for prompt decision-making (Ahammad, Glaister and Gomes, 2020; Parker and Grote, 2022). However, such bottom-up self-organizing systems are uncommon as they are so difficult to establish and manage (Nguyen, Peltoniemi and Lamberg, 2022).

Nevertheless, proponents of Chaos Theory claim that 'the system knows what to do in a turbulent environment' (Mason, 2007, p. 15). If autonomy is encouraged, an empowered and engaged workforce will be directed by the dominant self-reference in the system, rather than by orders or strategic plans from above (Wheatley, 1994). Self-reference is the spontaneous organization that occurs in states of organizational *laissez-faire* (Yang, 2015) around shared beacons, such as the sense of identity, values, or organizational culture that characterize strategically agile organizations (Ahammad, Glaister and Gomes, 2020; Kavanagh and Ashkanasy, 2006). These formal or informal references form institutional guidelines for conduct and decision-making within the organization's workforce.

In practical terms, self-referencing can be shaped around formal organizational guidelines (such as a corporate mission), worker handbooks, or codes of conduct. But these tend to be static and counter-productive for the development of strategic agility and the capacity for organizational self-alignment. References of an informal nature (linked to corporate culture or shared social convictions, for example) are more organic and adapt better to contextual change. However, they are outside of the influence of management and therefore will not necessarily be aligned with the firm's external and strategic evolution (Robbins *et al.*, 2010). In fact, research has repeatedly found examples where self-referenced cohesion within work teams has led to resistance to change rather than adaptive capacity (Mach et al., 2010; Whittington, 1990).

One kind of organizational reference that can potentially stimulate agility and favour the self-referenced alignment of an organization's workforce around the underlying patterns defining the complex adaptive system is the use of digitally enhanced HRM algorithms. These can be calibrated to reflect the defining patterns and deterministic rules behind the apparent randomness of the complex systems that connect a firm's internal organization with its external environment, and with its strategic trajectory. HRM algorithms therefore have the potential to serve as dynamic references around which a workforce in such a complex adaptive system can self-organize to achieve strategic agility.

Where HRM algorithms are implemented, workers have been found to be more agile when adapting their habits and reporting to satisfy certain references

(Tambe, Cappelli and Yakubovich, 2019). Algorithms shape the behaviour of and relationship between workers and clients to facilitate a new form of self-control and agility (Bucher, Schou and Waldkirch, 2021). Employees gain the means for self-organizing in synchrony with change (Kellogg, Valentine and Christin, 2020). The use of HRM algorithms as a reference will not ensure managerial command over change, because this cannot be predicted or controlled, but it can offer a certain predictable range of action. In other words, HRM algorithms promote strategic agility while maintaining some order, offering firms greater opportunities for proactive strategic renewal by limiting the costs derived from organizational resistance to anticipated change (Teece, 2020).

However, much of the HRM algorithm literature has focused on how these tools are often used to counter organizational agility and obstruct renewal (Duggan *et al.*, 2020; Kellogg, Valentine and Christin, 2020; Leicht-Deobald *et al.*, 2019; Tarba *et al.*, 2023). HRM algorithms can indeed be used to impose track-specific control, monitoring, and the legitimization of the status quo (Duggan *et al.*, 2020). Depending on how they are implemented, rather than being facilitators of strategic agility, algorithms applied to HR management can help to reinforce the conformity, standardization and internal mechanics of firms (Leicht-Deobald *et al.*, 2019). This happens when they are used from a short-term efficiency-driven logic, which has been found to favour employee compliance with static mechanisms (Kellogg, Valentine and Christin, 2020). This might help HR management to be less biased in their decision-making (Parry and Strohmeier, 2014), but will contribute little to the development of agile internal HR alignment to facilitate strategic renewal.

To stimulate such agility, HRM algorithms must be calibrated to offer references that foster flexibility and autonomy, not compliance and authority (Zhou *et al.*, 2021). Although the latter is still reported in many cases of the low-end gig industry (Leicht-Deobald *et al.*, 2019), researchers have observed a general shift in the use of HRM algorithms towards the generation of greater workforce self-organization and self-motivation to advance task performance and organizational agility (Bucher, Schou and Waldkirch, 2021; Duggan *et al.*, 2020). The use of HRM algorithms is increasingly raising organizations' potential for strategic agility and alignment capacity (Ahammad, Glaister and Gomes, 2020), either to respond promptly (speed) to predicted change (turbulence), or to align appropriately (fit) when complex change has occurred (complexity) (Evans, 1992).

HRM algorithms are heuristic in nature, meaning they are generalizations that illustrate certain predictive or descriptive 'patterns' without defining their impact's causal direction (Cheng and Hackett, 2021). These 'smart heuristics' help firms to be more agile and to adapt to the environment by supporting better decisions with less effort (Gigerenzer and Todd, 1999; Maitland and Sammartino, 2015). Therefore, the use of algorithms is likely to boost organizational agility in terms of the speed and fit of response to market turbulence and complexity, which are necessary skills for effective strategic renewal. As such, when it comes to the relationship between external market change and subsequent strategic renewal, the use of HRM algorithms at the organizational level is likely to play a positive moderating role (Figure 1).

It is therefore hypothesized that:

H3a: The relationship between market turbulence and strategic renewal is stronger in firms that use HRM algorithms.

H3b: The relationship between market complexity and strategic renewal is stronger in firms that use HRM algorithms.

Data, variables and method

Research context

The context selected to test the hypotheses of this study is intentionally meant to intensify the relevance of the modelled variables (or groups of variables). In terms of strategic renewal (dependent variable), this study focuses on high-growth companies. Seminal studies have extensively discussed the need to adapt organizational structure to a firm's strategy (e.g. Miller, 1986; Hendry and Pettigrew, 1992; Vincent *et al.*, 2020). Thus, a strategy focused on firm scaling will require organizational change and strategic renewal.[1]

Regarding market turbulence and complexity (independent variables), we collected the data at the end of the fourth COVID wave (September/October 2021), a moment of high uncertainty and volatility for businesses. As for HRM algorithms (moderating variable), we targeted our survey on Spanish businesses. Spain is a country with a high degree of uncertainty avoidance (Hotsfede index of 86/100)[2] (Hofstede, 1980; Hofstede,

[1]Our evidence corroborates that firm growth rate is correlated with strategic renewal. In Table 6 we run a linear regression model to test the methodological consistency of our findings. We include 3-year average employee growth as the control variable. The coefficient linked to this variable is positive and highly significant.

[2]Uncertainty avoidance in Spain is notably higher than in other both developed and emerging countries. For instance, Spain scores 86 in the Hofstede uncertainty avoidance index, significantly surpassing English-speaking nations such as the United States (46), the UK (35), and Australia (51), as well as emerging economies such as China (30) and India (40). Interestingly, Spain appears in the same cluster of countries as those of French legal origin, exhibiting similar uncertainty avoidance to

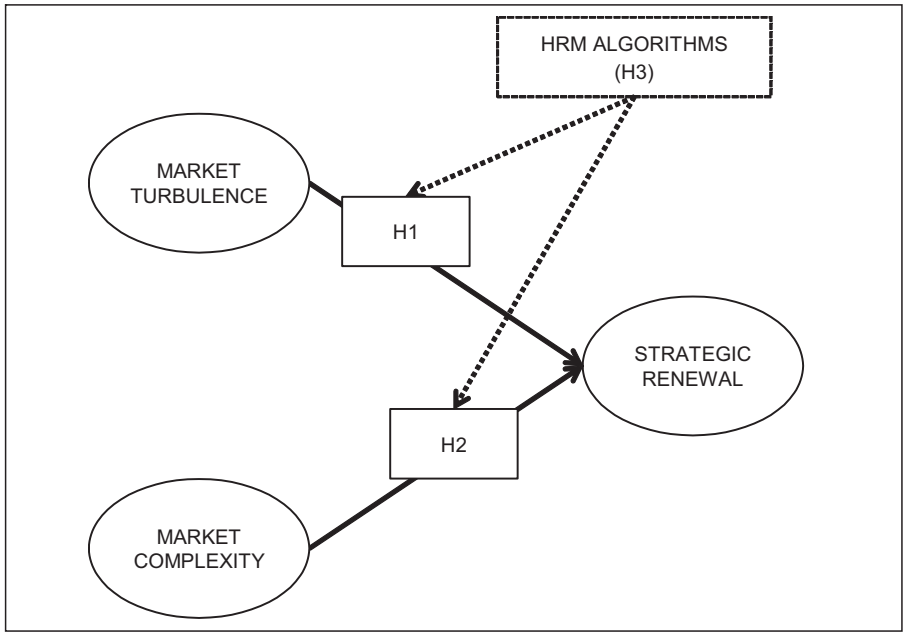

Figure 1. Conceptual model

2020). Individuals in Spain (including managers) are less prepared to operate in uncertain circumstances, and it is the kind of country where managers prefer to plan defect-free processes (Hofstede *et al.*, 2020; Reimann, Lünemann and Chase, 2008). Hence, in order to make more adequate decisions, Spanish managers are more prone to adopt data analytics systems than their peers in countries with less uncertainty avoidance (Hofstede *et al.*, 2020). Spain also falls at the mid-points of the individualism and power-distance spectrums, between the tight and individualist Anglo-Germanic cultures (Hofstede, 1980; Hofstede, 2023) and the high-power-distance, collectivist Asian cultures (Xing and Sims 2016; Xing, 2016; Xing and Starik, 2017). We therefore view Spain as an ideal setting for analysing the adoption of HRM algorithms and examining their impact on business renewal strategies.

Database

A purpose-built survey was designed and implemented on a population of Spanish growth-oriented enterprises. The technical specifications relative to the sampling procedure are shown in Table 1. We start by identifying the population using the following restricting criteria in the SABI database:[3] (1) firms with 10 employees or more, (2) growth rate in employment of at least 10% over a period of three years, and (3) relevant industries that represent the Spanish business fabric. On this basis, we identified a population of 2394 firms. We sought to produce a statistically representative survey. Using a Gaussian distribution and a confidence level of 95%, we found the minimum target sample size to be 332 firms. The survey began with a pilot questionnaire, which was presented to four managers to ensure that the questions were clear and suitable for the study's proposed objectives. A specialized survey collection firm, with extensive experience in market research, contacted firms via Computer-Aided Telephone Interviewing (CATI) from September to October 2021, the average survey time being 20 min. About 509 valid questionnaires were obtained, which is considerably above the minimum sample size required (332). The resulting sample contains a profile of firms like that found in the population.

We controlled for non-response bias (NRB) and common method variance (CMV). To assess NRB, we compared early and late respondents (first and last decile) for the items forming the dependent and independent variables (Armstrong and Overton, 1977). The *t*-test presented no statistically significant differences between early and late respondents (p-value > 0.1). We also compared the number of employees of responding and non-responding firms. The differences between the two groups were not statistically significant at the usual levels (p-value > 0.1).

CMV occurs when the dependent and independent variables are measured using the same response technique, in our case a survey (Podsakoff *et al.*, 2003). It was assessed following the recommendations of Car-

France (86) and Brazil (76). Japan (92) and Russia (95), however, are exceptions with slightly higher uncertainty avoidances than Spain.

[3]A Bureau Van Dijk (BvD) service that provides financial and accounting information on all Spanish firms (http://sabi.bvdep.com)

Table 1. Technical specifications of the sample

Population	
Universe	Growth-oriented enterprises
Source	SABI database (BvD)
Geographical area	Established in Spain, operating in the EU
Population	2394 enterprises
Methodology	Structured questionnaire
Composition and firm size of the population	
Industrial composition	NAICS 11 (2.7%), NAICS 21-23 (11.9%), NAICS 31 (5.3%), NAICS 32 (9.7%), NAICS 33 (16.7%), NAICS 42 (11.6%), NAICS 44-45 (4.8%), NAICS 48-49 (4.9%), NAICS 51-56 (22.1%), NAICS 61-62 (2.2%), NAICS 71-72 (3.8%) & NAICS 81 (4.3%)
No. of employees	73.82
Sampling procedure	
Type of interview	CATI (Computer-Assisted Telephone Interviewing)
Sample design	Random selection of sampling units
Confidence level	95%
Min. representative sample size	332 enterprises
Sample size	509 enterprises
Response rate	21.26%
Sampling error (p=q=0.50)	±5.13%
Composition and firm size of the sample	
Industrial composition	NAICS 11 (2.0%), NAICS 21-23 (11.8%), NAICS 31 (5.9%), NAICS 32 (11.8%), NAICS 33 (17.9%), NAICS 42 (14.5%), NAICS 44-45 (3.3%), NAICS 48-49 (3.9%), NAICS 51-56 (21.0%), NAICS 61-62 (2.0%), NAICS 71-72 (3.3%), NAICS 81 (2.6%)
No. of employees	74.98

son (2007) and Schwens *et al.* (2018), who propose conducting a confirmatory factor analysis. The fit of the model with one factor that includes all Likert scale items used in the study presented unsatisfactory goodness-of-fit levels (Tucker-Lewis index (TLI) = 0.721 and comparative fit index (CFI) = 0.773, with the acceptance range for these measures being higher than 0.900; and root mean square error of approximation (RMSEA) = 0.097, with the acceptance range being between 0.050 and 0.080). According to this test, CMV does not affect the results of the study.

Method

The model was estimated by means of a covariance-based structural equation model (CB-SEM) as the objective of the study is theory testing and confirmation as opposed to theory development and prediction, for which partial least squares (PLS-SEM) is preferred (Hair, Ringle and Sarstedt, 2011). In addition, CB-SEM is particularly useful for analysing structural relationships between latent constructs and provides global goodness-of-fit indicators that particularly emphasize theory testing. The moderation effects were analysed by splitting samples (Hair, Ringle and Sarstedt, 2011).

Key variables

The dependant variable (DV) incorporates indicators measuring the means of *Strategic renewal* (Billinger and Jacobides, 2007), a set of five items measured on a 7-point Likert scale from 1 = Total disagreement to 7 = Total agreement, namely Degree of flexibility in buying and selling along the value system; Capacity for offering new products and solutions; Greater responsiveness; Capacity for addressing specialized needs; and Capacity for offering complete/tailored solutions.[4]

[4]Additional details about the measurement of all variables can be found in the Online Appendix.

Table 2. Factor loadings and reliability analysis

Construct/ Items	Mean (Std dev.)	Factor loading (*t*-value)	R^2	Composite reliability	Variance extracted
Strategic renewal (SR)				0.868	0.570
SR1	5.503 (1.751)	0.832 (28.478)	0.692		
SR2	5.862 (1.546)	0.891 (28.652)	0.794		
SR3	5.580 (1.424)	0.808 (30.371)	0.653		
SR4	5.808 (1.417)	0.794 (28.317)	0.630		
SR5	5.254 (1.522)	0.736 (26.450)	0.542		
Market turbulence (MT)				0.852	0.551
MT1	6.239 (1.141)	0.790 (16.822)	0.692		
MT2	5.920 (1.209)	0.834 (21.616)	0.794		
MT3	6.290 (1.029)	0.755 (18.043)	0.653		
MT4	5.840 (1.321)	0.767 (16.567)	0.630		
Market complexity (MC))				0.845	0.550
MC1	5.878 (1.343)	0.791 (17.081)	0.626		
MC2	5.272 (1.826)	0.783 (19.412)	0.613		
MC3	5.789 (1.396)	0.865 (20.616)	0.748		

All the factor loadings are significant for a level of $p < 0.01$.

Table 3. Human resource management algorithms (HRMAs) by class size

No. of employees	Class size	Frequency	Percentage	%HRMA
[10–49]	Small enterprises	399	78.4	34.1
[50–249]	Medium-sized enterprises	89	17.5	51.7
[250–999]	Large enterprises	16	3.1	56.2
[1–10k]	Very large enterprises	5	1.0	60.0
[10–10k]	Total	509	100	38.1

Items were loaded on a single component (Kaiser-Meyer-Olkin (KMO) = 822, Bartlet's test $\chi^2 = 1253.26$ ($p = 0.000$), with total vector error (TVE) = 67.01% (see Table 2). Factor loadings were higher than the recommended 0.700 threshold, while the measures for internal consistency—Cronbach's alpha ($\alpha = 0.796$)—and reliability (average variance extracted (AVE) = 0.570, composite reliability (CR) = 0.868) were equally satisfactory (Hair *et al.*, 2010).

The independent variables (IVs) were *Market Turbulence* and *Market Complexity*, which were operationalized using 7-point Likert scale items and validated according to Greenley and Oktemgil (1997) and Oktemgil and Greenley (1997), respectively. *Market Turbulence* is compounded by a set of four items, namely price competition, product/service competition, changes in customer needs, and new product/service launch, whereas *Market Complexity* is a set of three items, namely complexity of competitors, complexity of production, and complexity of customers. The internal consistency of the scales was measured using Cronbach's alpha ($\alpha_{MketTurb} = 0.791$ and $\alpha_{MketComp} = 0.802$). Scale reliability measures were satisfactory (Table 4), the values for *Composite Reliability* ($CR_{MketTurb} = 0.852$; $CR_{MketComp} = 0.845$) and for *Average Variance Extracted* ($AVE_{MketTurb} = 0.551$ and $AVE_{MketComp} = 0.550$) being over the recommended thresholds (Hair *et al.*, 2010) ($CR \cong 0.700$ and $AVE \cong 0.500$).

The moderating variable is binary. There are two reasons for this methodological choice. First, early adoption of new technology does not normally consider the intensity but rather the dichotomy of early/late adoption (Bolton, 1993; Baldwin and Lin, 2002; Liu *et al.*, 2024). We hence considered that a binary (or status) variable would fit better with the context of HRM algorithms, a technology that is not yet widely used among private businesses. Second, the objective of the study was to provide a statistical model for studying situations in which the degree of predictability of the independent variables varied as a function of being in one or another of the groups of firms (having or not having HRM algorithms) rather than providing a simple generalization in which the predictors are scored depending on a continuous moderating variable. To measure HRM algorithms,

Table 4. Human resource management algorithms (HRMAs) by industry

NAICS	Description	Frequency	Percent	%HRMA	Salary
32	Wood, petroleum, chemical and pharmaceutical manufacturing	60	11.8	46.7	€29.2k
42	Wholesale trade	74	14.5	45.9	€24.2k
31	Food, beverage, textile and apparel manufacturing	30	5.9	43.3	€29.2k
51–56	Professional, technological and administrative services	107	21.0	39.3	€35.4k
44–45	Retail trade	17	3.3	35.3	€24.2k
33	Machinery, vehicles and electronics manufacturing	91	17.9	33.0	€29.2k
21–23	Extraction, utilities and construction	60	11.8	31.7	€28.0k
11	Agriculture, forestry, fishing and hunting	10	2.0	30.0	€15.7k
48–49	Transportation and warehousing	20	3.9	30.0	€24.8k
61–62	Education and healthcare services	10	2.0	30.0	€31.0k
71–72	Entertainment, catering and accommodation services	17	3.3	29.4	€16.1k
81	Other services	13	2.6	23.1	€21.4k
All	Total	509	100	38.1	€24.5k

Data from Spanish National Institute of Statistics (INE) wage structure survey. Values correspond to annual salary in thousands of euros.

we asked whether the firm possesses HRM decision-making systems based on machine-learning classifiers (see Charlier and Kloppenburg, 2017 or Czarnowski and Pszczólkowski, 2020). The variable takes the value '1' if the firm responds affirmatively and '0' otherwise.

Results

Descriptive evidence

Based on the descriptive evidence shown in Tables 3 (by firm size) and 4 (by industry), certain firm- and industry-level observations can be made regarding the adoption of HRM algorithms. More than three-quarters of the sampled firms are small enterprises (10–49 employees), whereas large/very large enterprises represent only 4.1% of the sample. Interestingly, the adoption of HRM algorithms increases with firm size. However, the adoption rate rises relatively slowly once companies have more than 50 employees—hence among relatively small firms, their size seems to be an especially important factor for the adoption of HRM algorithms.

A wide range of industries are included (see Table 4), with the manufacturing (35.9%) and professional/technological (21.0%) industries being the most heavily represented. Our descriptive evidence suggests that while HRM algorithms are present in all industries, their adoption rate seems higher in those with higher average pay rates. For instance, the top four industries in terms of HRM algorithm adoption had an average annual gross payroll of 29,500 euros, which is 6200 euros higher than that of the bottom four industries.

Hypothesis testing

Figure 2 shows the results of the main analysis. We started by estimating the parameter for the relationship between *Market Turbulence* and *Strategic Renewal*, which was positive and statistically significant [$\beta_{MketTurb \rightarrow StraRenw} = 0.242^{(t=3.13;\, p=0.002)}$], thus supporting Hypothesis 1. We continued by estimating the parameter for the relationship between *Market Complexity* and *Strategic Renewal*, which was also positive and statistically significant [$\beta_{MketComp \rightarrow StraRenw} = 0.417 (t = 5.28;\, p = 0.000)$], therefore supporting Hypothesis 2.

Moderation group analysis was carried out by splitting the sample into firms with and without HRM algorithms. After restricting these parameters, the model's goodness-of-fit was estimated (χ^2 Satorra–Bentler 46.548) and restricted for equality in both subsamples. There were changes in goodness-of-fit (χ^2 Satorra–Bentler 54.007) when testing a moderator group analysis that evaluated whether the model coefficients significantly differ between the group of firms that had HRM algorithms and the group that did not. Furthermore, a χ^2 difference test between the models revealed statistically significant differences, thus confirming that HRM algorithms moderate the relationships between IVs and the DV. As for the estimation of the parameters, Hypothesis 3a predicted that the relationship between *Market Turbulence* and *Strategic Renewal* is stronger for firms that use HRM algorithms. The results support this proposal [$\beta_{MketTurb \rightarrow StraRenwforHRMalg} = 0.588$ ($t = 5.16;\, p = 0.000$) vs. ($\beta_{MketTurb \rightarrow StraRenwfornon-HRMalg} = 0.091 (t = 1.01;\, p = 0.312)$]. However, Hypothesis 3b, that the relationship between *Market Complexity*

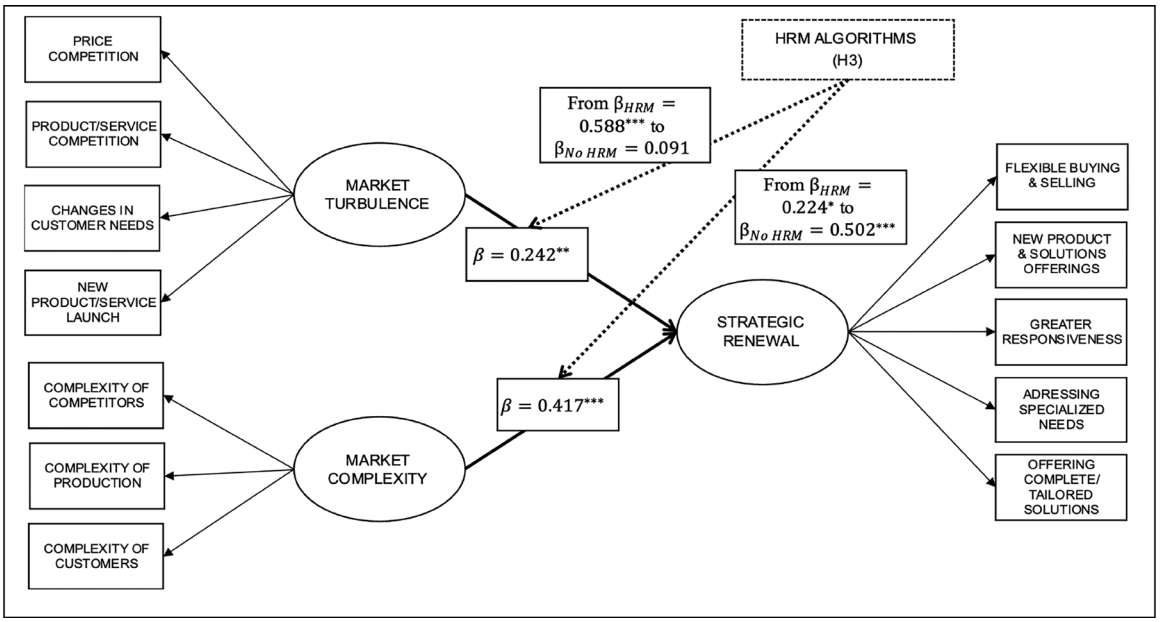

Figure 2. Parameter estimation

Table 5. Two sample t*-tests for turbulence, complexity and renewal*

	Mean		Two sample *t*-test
Variables	Without HRMA (315)	With HRMA (194)	*p*-value
Market turbulence	−0.118	0.184	0.044
Market complexity	−0.050	0.074	0.362
Strategic renewal	−0.140	0.223	0.022

Human resource management algorithm (HRMA).

and *Strategic Renewal* will be stronger for firms using HRM algorithms, is not supported by the results of the group analysis [$\beta_{MketComp \rightarrow StraRenwforHRMalg} = 0.224$ ($t = 2.43$; $p = 0.015$) vs. ($\beta_{MketComp \rightarrow StraRenwfornon-HRMalg} = 0.502$($t = 5.47$; $p = 0.000$)].

Robustness tests

Supplementary analysis was undertaken to substantiate the internal and methodological consistency of results. The results suggest that HRM algorithms strengthen the relationship between market turbulence and strategic renewal, but do not influence that between market complexity and strategic renewal. For this result to be internally consistent, we would need the adoption of HRM algorithms to be higher in more turbulent environments, and not statistically different in more complex environments. This is analysed with a *t*-test. We compare how the linear prediction of our DV and IVs differ in terms of HRM algorithm adoption. The results reported in Table 5 suggest that while HRM algorithms are more common in highly turbulent markets and in renewal-intensive firms, there are no statistically significant differences when it comes to market complexity. This result confirms that the findings are internally consistent.

In relation to methodological consistency, we also ran the moderation analysis through a linear regression (OLS), which enables introduction of the following control variables to the analysis: (1) firm age, (2) 3-year average employee growth rate, (3) class size dummies, and (4) industry dummies. The resulting model has good explanatory capacity ($R^2 = 0.321$). Consistent with the CB-SEM analysis, direct effects are highly significant (p-value < 0.001) and HRM algorithms only moderate the relationship between market turbulence and strategic renewal (p-value < 0.05). Based on this evidence, we conclude that our results are consistent for all methodological approaches.

Discussion and conclusions

Discussion of results

The study presented in this paper adopted the premise of Chaos Theory to explain the impact of market turbulence and complexity on strategic renewal (Levy, 1994; Mason, 2007). Furthermore, the proposed model

Table 6. Ordinary least squares model with control variables

	(1)	(2)	(3)
Market turbulence	0.256***	0.207**	0.251***
	(0.058)	(0.064)	(0.058)
	0.000	*0.001*	*0.000*
Market complexity	0.383***	0.384***	0.412***
	(0.076)	(0.075)	(0.094)
	0.000	*0.000*	*0.000*
HRM algorithms	0.208	0.190	0.213
	(0.127)	(0.126)	(0.127)
	0.102	*0.131*	*0.095*
HRM algorithms*market turbulence		0.187*	
		(0.084)	
		0.027	
HRM algorithms*market complexity			−0.088
			(0.097)
			0.368
Firm age (in years)	0.007**	0.007**	0.007**
	(0.003)	(0.003)	(0.003)
	0.009	*0.007*	*0.008*
Firm growth rate (%)	0.636**	0.650**	0.630**
	(0.209)	(0.210)	(0.210)
	0.002	*0.002*	*0.003*
Constant	−0.634**	−0.638**	−0.634**
	(0.219)	(0.216)	(0.219)
	0.004	*0.003*	*0.004*
Observations	509	509	509
R^2	0.321	0.327	0.323
Class size dummies	Yes	Yes	Yes
Industry dummies	Yes	Yes	Yes

Robust standard errors in parentheses. P-values in italics $^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$.

assessed the moderating effect of HRM algorithms on the relationships between external market change and strategic renewal. This was achieved by collecting primary survey data on over 500 growth-oriented firms in order to test the theoretical predictions with a CB-SEM. The results mostly validate our model, with the nuance that HRM algorithms are found to have a positive moderating role on the relationship between external change and strategic renewal, but only in the case of market turbulence. No moderation was identified for market complexity.

A possible interpretation of this result is that turbulence has a dynamic component whereby tendency identification is a key factor for proactively renewing strategies at the necessary 'speed' to maintain competitive advantage. Such tendency identification using business analytics and algorithmic managerial assistance tools is already a consolidated practice in many organizations. It is therefore apparently simple to use HRM algorithms to stimulate strategic agility and alignment.

However, the use of HRM algorithms in the case of market complexity to achieve and maintain an optimal strategic 'fit' with the changing environment is likely to be less applicable. Using HRM algorithms to align in complex environments characterized by a multifarious configuration of many interlinked external variables that all affect strategic competitiveness at once is likely to be a much more foreign practice to most managerial teams. In fact, managers may be challenged by the counter-intuitiveness of using HRM algorithms, in that the greater the external market complexity, the more management has to step away from the operational helm of the organization for the sake of strategic agility. In complex markets, managers may be somewhat reluctant to leave it up to algorithms to offer the references around which the HR organization can spontaneously align to achieve better strategic fit. So, managerial culture needs to change, and larger amounts of empirical evidence must be gathered in order to boost confidence in the benefits of running agile self-organizing firms that use effective strategic renewal, facilitated by the use of HRM algorithmic tools, to perpetually operate on the edge of chaos.

Implications for theory and practice

This study makes four important contributions to the literature. First, it recovers the principles of Chaos Theory: the theory was once hailed as a highly promising avenue for the analysis of strategy formulation in contexts of change and turmoil (Levy, 1994), but, despite its theoretical robustness, it has fallen out of favour some-

what in recent decades owing to its poor practical applications (Smith, 2001). The self-organization aspect of Chaos Theory was considered ineffective from an organizational perspective in the case of corporate strategy formulation (Smith, 2001). This is partly the reason why this theory has not received much academic attention in recent decades, which is surprising considering how environmental intricacy, uncertainty, and a convulsive strategic context have been generating precisely the complex adaptive systems in which the theory is meant to be applied. However, the findings of this study indicate that the novel but increasing use of HRM algorithms could be effective for fulfilling the intricate self-organization role by providing the strategic alignment between internal and external change upon which Chaos Theory is based.

Second, the study is one of the first to characterize certain descriptive patterns in the adoption of HRM algorithms; for example, by exploring industrial and firm size heterogeneity. Beyond the common approaches from the technology acceptance model (Davis, 1989) based on planned behavioural theories (Ajzen, 1991) regarding specific perceptions of technology usefulness and its ease of use, the results of the study show greater multi-level influence guiding not only the choice, but also the outcomes of the choice, to adopt technology. As such, the effectiveness of such analytical tools, which in turn warrants their adoption, may stem from configurations of macro, cultural, organizational and specific managerial factors working in consonance (Queiroz *et al.*, 2023).

The results highlight the potential role of HRM algorithms as the missing tool that might supply the internal dynamic reference around which a workforce can self-organize. HRM algorithms may be what corporate strategy research needs in order to better conceptualize dynamic strategy formulation from a chaos perspective in complex states of perpetual turmoil, rather than based on the steady-state (Masson, 2007).

Third, the study contributes to the analysis of HRM algorithms from a different angle from the currently predominant one in the HRM algorithm literature (Zhou *et al.*, 2021). The use of eHRM or algorithms to assist in human resource management tasks is being especially scrutinized by researchers from a social or labour relations perspective (Bucher, Schou and Waldkirch, 2021; Kellogg, Valentine and Christin, 2020; Leicht-Deobald *et al.*, 2019; Parry and Strohmeier, 2014); and this is especially so regarding their (inappropriate) use within the gig-economy (Bucher, Schou and Waldkirch, 2021; Duggan *et al.*, 2020). Whereas such literature addresses the debate from the micro or meso levels of analysis, our study makes a novel contribution by offering a macro perspective on the current debate (Pereira *et al.*, 2023). Few studies have analysed, as this study has done, the impact of the use of HRM algorithms on strategic performance in the wider economy (Cheng and Hackett, 2021), and even fewer have explored their role in terms of strategic agility within complex adaptive systems. Therefore, our study highlights the potential role of HRM algorithms as the missing tools that might supply the internal dynamic reference around which self-organizing workforces can rapidly align in order to provide the agility required for strategic renewal.

Fourth, by adopting a different perspective, the study and its results paint a very different picture of the potential impact and role of HRM algorithms in organizations. In contrast to the fear that they will impose compliance and take over decision-making, our findings indicate that HRM algorithms can be used to foster better self-organization of individual work habits and decision-making. They can therefore serve as tools to help establish the type of self-organizing workforce that was previously thought to be too complex and chaotic to manage effectively. Following Kemp (2023), who categorized how companies can achieve competitive advantage from the use of advanced digital assistance, when HRM algorithms are involved, our results indicate that an advantage comes from increased 'recasting' abilities that overcome strategic myopia and improve the 'adaptation of internal technologies and routines to contextualize a firm's system of task, relational, and strategic interdependencies' (Kemp, 2023, p. 18). This contrasts with the 'grounding' perspective that has mostly been used until now to analyse HRM algorithms, where scant evidence of competitive advantage from the compliance enforcement role of HRM algorithms has been found.

From a practitioners' point of view, the results of our study provide indications as to how best use HRM algorithms. We make a case for the possible use of HRM algorithms as a force for change and competitiveness, in contrast with their much-criticized conformity role. This is valuable knowledge in the context of rapidly advancing AI-based tools that could potentially make a significant contribution to corporate management and strategic alignment capabilities. However, empirical research tends to indicate that although companies are rapidly taking up these new technologies, very few (less than 10%) achieve their full implementation within their operations (Wamba *et al.*, 2023). Although exploratory strategic recasting goals are found to often motivate the adoption of these technologies, when implementing them, the actual use that managers make of them is based on supporting the current strategic trajectory rather than on finding new, better aligned and more agile ones (Wamba *et al.*, 2023).

Our study highlights the importance of strategic agility, and the inappropriateness of static HRM practices. As such, it encourages management on the edge of chaos in a state of continual strategic effervescence to use algorithms as a means for perpetual strategic alignment. This hints that chaos is manageable with the right

algorithmic help, and that there is a case to be made for the adoption of self-organizing, bottom-up managerial approaches, especially in contexts of complex adaptive systems.

Limitations and future research

Like any other theoretical model, the model constructed for this study needs to be further validated and contextualized in replication studies. For reasons of rigour and theoretical consistency, our model and the items used in its composition replicated those that have been tried and accepted in the relevant literature. Given that the model produced the expected results, future research could potentially fine-tune and disaggregate the factored constructs to test specific items or reconstruct the measures of market turbulence, complexity and strategic renewal. Future research could also extend the analysis to other variants of the complex adaptive systems that organizations face.

Because the main research question addressed in the study is a variance interrogation, future process-oriented qualitative research could offer valuable complementary results to those already obtained. Working with the corroborated theoretical model, such research could pinpoint the underlying generative mechanisms and contingencies at play when HRM algorithms are used during strategic alignment. Through qualitative research, future studies could extend the process further and investigate the specific uses and calibrations of HRM algorithms that best stimulate strategic agility and contribute to self-organization.

The cross-sectional nature of the data used in the study does not allow for longitudinal heterogeneity analyses. As a result, future work based on longitudinal data seems necessary in order to gain a better understanding of the temporal evolution of the strategic alignment of organizations using HRM algorithms. Likewise, the conclusions generated in this study are the result of the analysis of growth-oriented firms. We believe that our findings and recommendations can be extended to organizations with different characteristics, but we encourage researchers to engage in new studies dealing with the wide spectrum of scenarios and business types that might influence the moderating impact of HRM algorithms on the strategic alignment capacity of organizations in turbulent and complex environments. It may be of special interest to contrast the role and use made of HRM algorithms within strategic alignment across different cultural settings with different degrees of uncertainty avoidance and importance attached to status and power relations (Hofstede, 1980; Hofstede G.J., 2020; Xing and Sims, 2016). The current study has the benefit of being set in a high-uncertainty-avoidance country, Spain, which at the same time falls at the mid-points of the individualism and power-distance spectrums, between the tight, individualist cultures found in Germanic, Scandinavian and Anglosphere countries and the high-power-distance, collectivist Asian and Southern cultures (Hofstede G., 1980; Hofstede G.J., 2023; Xing, 2016; Xing and Starik, 2017). Considering the rise of transculturality and relational economics (Montecinos, Grünfelder and Wieland, 2023), new research could analyse the potential role of the relational view of culture and transculturality by examining whether the adoption of internal business analytics, particularly HRM algorithms, enhances agile strategic renewal similarly across distinct cultural spectrums. Will such AI-based HR management tools contribute to the convergence of HR practices across cultures, or will culture lead to the distinct managerial use of these tools?

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References

Abdulla, H. (2022). 'H&M Group, Norrøna under fire in Norway over environmental claims', *Just Style*, June 2023. Retrieved in April 2024 from: http://www.just-style.com/news/hm-group-norrona-under-fire-in-norway-over-environmental-claims.

Abdulla, H. (2023a). 'Nike under fire as unions allege OECD guidelines 'breach' in supply chain', *Just Style*, March 2023. Retrieved in April 2024 from: http://www.just-style.com/news/shein-adidas-nike-temu-collared-over-uyghur-forced-labour-concerns/.

Abdulla, H. (2023b). 'Global fashion brand winners and losers in 2023', *Just Style*, December 2023. Retrieved in April 2024 from: http://www.just-style.com/features/global-fashion-brand-winners-and-losers-in-2023/?cf-view.

Ahammad, M. F., K. W. Glaister and E. Gomes (2020). 'Strategic agility and human resource management', *Human Resource Management Review*, **30**, p. 100700.

Ajzen, I. (1991). 'The theory of planned behavior', *Organizational Behavior and Human Decision Processes*, **50**, pp. 179–211.

Armstrong, J. S. and T. S. Overton (1977). 'Estimating nonresponse bias in mail surveys', *Journal of Marketing Research*, **14**, pp. 396–402.

Baldwin, J. and Z. Lin (2002). 'Impediments to advanced technology adoption for Canadian manufacturers', *Research Policy*, **31**, pp. 1–18.

Battistella, C. and A. F. de Toni (2018). 'Complex business models: Pacorini at the edge of chaos', *Strategic Change*, **27**, pp. 379–393.

Bechtold, B. L. (1997). 'Chaos theory as a model for strategy development', *Empowerment in Organizations*, **5**, pp. 193–201.

Billinger, S. and M. G. Jacobides (2007). 'Fending off commoditization and softening competition through strategic boundary design', Industry Studies Working Paper 2007-07.

Black, J. and G. Farias (1997). 'Genesis of complexity cycles'. In *8th Annual International Conference of The Society for Chaos Theory in Psychology and Life Sciences*. Boston University, Boston, MA (Vol. 31), SCTPLS, USA.

Bolton, M. K. (1993). 'Organizational innovation and substandard performance: When is necessity the mother of innovation?', *Organization Science*, **4**, pp. 57–75.

Brea-Solís, H. and E. Grifell-Tatjé (2023). 'Winners and losers of the productivity gains of the American agricultural sector', *Applied Economics*, **55**, pp. 3915–3930.

Brown, S. L. and K. M. Eisenhardt (1997). 'The art of continuous change: linking complexity theory and time-paced evolution in relentlessly shifting organizations', *Administrative Science Quarterly*, **42**, pp. 1–34.

Bucher, E. L., P. K. Schou and M. Waldkirch (2021). 'Pacifying the algorithm – anticipatory compliance in the face of algorithmic management in the gig economy', *Organization*, **28**, pp. 44–67.

Bustinza, O. F., F. Vendrell-Herrero and E. Gomes (2019). 'Unpacking the effect of strategic ambidexterity on performance: a cross-country comparison of MMNEs developing product-service innovation', *International Business Review*, **29**, p. 101569.

Carson, S. J. (2007). 'When to give up control of outsourced new product development', *Journal of Marketing*, **71**, pp. 49–66.

Chakravarthy, B. (1997). 'A new strategy framework for coping with turbulence', *Sloan Management Review*, **38**, pp. 69–82.

Cheng, M. M. and R. D. Hackett (2021). 'A critical review of algorithms in HRM: definition, theory, and practice', *Human Resource Management Review*, **31**, p. 100698.

Czarnowski, I. and P. Pszczólkowski (2020). 'A novel framework for decision support system in human resource management', *Procedia Computer Science*, **176**, pp. 1548–1556.

Davis, F. D. (1989). 'Perceived usefulness, perceived ease of use, and user acceptance of information technology', *MIS Quarterly*, **13**, pp. 319–340.

Doz, Y. (2020). 'Fostering strategic agility: how individual executives and human resource practices contribute', *Human Resource Management Review*, **30**, p. 100693.

Doz, Y. L. and M. Kosonen (2010). 'Embedding strategic agility: a leadership agenda for accelerating business model renewal', *Long Range Planning*, **43**, pp. 370–382.

Duggan, J., U. Sherman, R. Carbery and A. McDonnell (2020). 'Algorithmic management and app-work in the gig economy: a research agenda for employment relations and HRM', *Human Resource Management Journal*, **30**, pp. 114–132.

Evans, P. (1992). 'Management development as glue technology', *Human Resource Planning*, **15**, pp. 85–106.

Frederick, W. C. (1998). 'Creatures, corporations, communities, chaos, complexity: a naturological view of the corporate social role', *Business and Society*, **37**, pp. 358–389.

Gannon, K. E., D. Conway, M. Hardman, A. Nesbitt, S. Dorling and J. Borchert (2023). 'Adaptation to climate change in the UK wine sector', *Climate Risk Management*, **42**, p. 100572.

Gigerenzer, G. and P. M. Todd (1999). 'Fast and frugal heuristics: the adaptive toolbox'. In *Simple Heuristics That Make Us Smart*, pp. 3–34. Oxford: Oxford University Press.

Goodwin, B. (1999). 'Reviews: corporate DNA: learning from life, Ken Baskin', *Emergence*, **1**, pp. 160–162.

Grant, R. (2016). *Contemporary Strategy Analysis: Text and Cases Edition*. London: John Wiley and Sons Ltd.

Greenley, G. E. and M. Oktemgil (1997). 'An investigation of modulator effects on alignment skill', *Journal of Business Research*, **39**, pp. 93–105.

Hair, J. F., C. M. Ringle and M. Sarstedt (2011). 'PLS-SEM: indeed a silver bullet', *Journal of Marketing Theory and Practice*, **19**, pp. 139–152.

Hair, J. F., W. C. Black, B. J. Babin and R. E. Anderson (2010). *Multivariate Data Analysis*. New York: Pearson.

Hendry, C. and A. Pettigrew (1992). 'Patterns of strategic change in the development of human resource management', *British Journal of Management*, **3**, pp. 137–156.

Hinsch, C., R. Felix and P. A. Rauschnabel (2020). 'Nostalgia beats the wow-effect: inspiration, awe and meaningful associations in augmented reality marketing', *Journal of Retailing and Consumer Services*, **53**, p. 101987.

Hofstede, G. (1980). 'Culture and organizations', *International Studies of Management and Organization*, **10**, pp. 15–41.

Hofstede, G. J. (2020). 'Understanding culture: the unwritten rules of the game', *Psychology Review Magazine*, **25**, pp. 12–15.

Hofstede, G. J. (2023). 'A relational view on culture and transculturality'. In J. Baumann, T. Grünfelder and J. Wieland (eds.), *A Relational View on Cultural Complexity: Implications for Theory and Practice*, pp. 67–86. Cham: Springer International Publishing.

Hofstede, G., C. Van Deusen, C. Mueller and T. Charles (2020). 'What goals do business leaders pursue?: A study in fifteen countries'. In M. DiDomenico, S. Vangan, N. Winchester, D. Boojihawon and J. Mordaunt (eds.), *Organizational Collaboration*, pp. 35–48. Oxon: Routledge.

Jacobides, M. G. and S. Billinger (2006). 'Designing the boundaries of the firm: from "Make, buy, or ally" to the dynamic benefits of vertical architecture', *Organization Science*, **17**, pp. 249–261.

Jamrog, J., M. Vickers and D. Bear (2006). 'Building and sustaining a culture that supports innovation', *People and Strategy*, **29**, pp. 9–19.

Jiang, F., X. Zheng, D. Fan, P. Zhang and S. Li (2021). 'The sharing economy and business model design: a configurational approach', *Journal of Management Studies*, **58**, pp. 949–976.

Junni, P., R. M. Sarala, S. Y. Tarba, Y. Liu and C. L. Cooper (2015). 'Guest editors' introduction: the role of human resources and organizational factors in ambidexterity', *Human Resource Management*, **54**, pp. 1–28.

Kavanagh, M. H. and N. M. Ashkanasy (2006). 'The impact of leadership and change management strategy on organizational culture and individual acceptance of change during a merger', *British Journal of Management*, **17**, pp. 81–103.

Kazakov, R., S. Howick and A. Morton (2021). 'Managing complex adaptive systems: a resource/agent qualitative modelling perspective', *European Journal of Operational Research*, **290**, pp. 386–400.

Kellogg, K. C., M. A. Valentine and A. Christin (2020). 'Algorithms at work: the new contested terrain of control', *Academy of Management Annals*, **14**, pp. 366–410.

Kemp, A. (2023). 'Competitive advantages through artificial intelligence: toward a theory of situated AI', *Academy of Management Review*, (In-Press).

Lane, D. and R. Maxfield (1996). 'Strategy under complexity: fostering generative relationships', *Long Range Planning*, **29**, pp. 215–231.

Leicht-Deobald, U., T. Busch, C. Schank, A. Weibel, S. Schafheitle, I. Wildhaber and G. Kasper (2019). 'The challenges of algorithm-based HR decision-making for personal integrity', *Journal of Business Ethics*, **160**, pp. 377–392.

Levy, J. S. (1994). 'Learning and foreign policy: sweeping a conceptual minefield', *International Organization*, **48**, pp. 279–312.

Lewin, A. Y. and H. W. Volberda (1999). 'Prolegomena on coevolution: a framework for research on strategy and new organizational forms', *Organization Science*, **10**, pp. 519–534.

Lewin, R. (1993). *Complexity: Life at the Edge of Chaos*. London, UK: The University of Chicago Press.

Lissack, M. R. (1997). 'Of chaos and complexity: managerial insights from a new science', *Management Decision*, **35**, pp. 205–218.

Liu, Y., J. M. Lee and C. Lee (2020). 'The challenges and opportunities of a global health crisis: the management and business implications of COVID-19 from an Asian perspective', *Asian Business and Management*, **19**, pp. 277–297.

Liu, Y., S. Collinson, S. C. Cooper and D. Baglieri (2022). 'International business, innovation and ambidexterity: a micro-foundational perspective', *International Business Review*, **31**, p. 101852.

Liu, Y., Y. Xing, F. Vendrell-Herrero and O. F. Bustinza (2024). 'Setting contextual conditions to resolve grand challenges through responsible innovation: a comparative patent analysis in the circular economy', *Journal of Product Innovation Management*, **41**, pp. 449–472.

Loon, M., L. Otaye-Ebede and J. Stewart (2020). 'Thriving in the new normal: the HR microfoundations of capabilities for business model innovation. An integrated literature review', *Journal of Management Studies*, **57**, pp. 698–726.

Mach, M., S. Dolan and S. Tzafrir (2010). 'The differential effect of team members' trust on team performance: The mediation role of team cohesion', *Journal of Occupational and Organizational Psychology*, **83**, pp. 771–794.

Mackay, N. (2024). 'The 10 most valuable wine brands from around the world', *SOMM Magazine*, January 2024. Retrieved in April 2024 from: http://mag.sommtv.com/2024/01/most-valuable-wine-brands/.

Maitland, E. and A. Sammartino (2015). 'Decision making and uncertainty: the role of heuristics and experience in assessing a politically hazardous environment', *Strategic Management Journal*, **36**, pp. 1554–1578.

March, J. G. (1991). 'Exploration and exploitation in organizational learning', *Organization Science*, **2**, pp. 71–87.

Mason, R. B. (2007). 'The external environment's effect on management and strategy: a complexity theory approach', *Management Decision*, **45**, pp. 10–28.

Massari, G. F. and I. Giannoccaro (2021). 'Investigating the effect of horizontal coopetition on supply chain resilience in complex and turbulent environments', *International Journal of Production Economics*, **237**, p. 108150.

Meininge"s International. (2024). 'Turbulent times for German wine producers', *Meininge"s International*, February 26, 2024. Retrived in April 2024 from: http://www.meiningers-international.com/wine/insights/turbulent-times-german-wine-producers

Miller, D. (1986). 'Configurations of strategy and structure: towards a synthesis', *Strategic Management Journal*, **7**, pp. 233–249.

Minbaeva, D. B. (2018). 'Building credible human capital analytics for organizational competitive advantage', *Human Resource Management*, **57**, pp. 701–713.

Montecinos, J. B., T. Grünfelder and J. Wieland (eds) (2023). *A Relational View on Cultural Complexity: Implications for Theory and Practice*. Cham: Springer International Publishing.

Nguyen, K., M. Peltoniemi and J. A. Lamberg (2022). 'Strategic renewal: Can it be done profitably?', *Long Range Planning*, **55**, p. 102179.

O'Reilly, C. A. (1982). 'Variations in decision makers' use of information sources: the impact of quality and accessibility of information', *Academy of Management Journal*, **25**, pp. 756–771.

Oktemgil, M. and G. Greenley (1997). 'Consequences of high and low adaptive capability in UK companies', *European Journal of Marketing*, **31**, pp. 445–466.

Parker, S. K. and G. Grote (2022). 'Automation, algorithms, and beyond: why work design matters more than ever in a digital world', *Applied Psychology*, **72**, pp. 1171–1204.

Parry, E. and S. Strohmeier (2014). 'HRM in the digital age: digital changes and challenges of the HR profession', *Employee Relations*, **36**, pp. 1146–1162.

Pereira, V., E. Hadjielias, M. Christofi and D. Vrontis (2023). 'A systematic literature review on the impact of artificial intelligence on workplace outcomes: a multi-process perspective', *Human Resource Management Review*, **33**, p. 100857.

Podsakoff, P. M., S. B. MacKenzie, J. Y. Lee and N. P. Podsakoff (2003). 'Common method biases in behavioral research: a critical review of the literature and recommended remedies', *Journal of Applied Psychology*, **88**, pp. 879–903.

Prakash, P. (2023). 'British Champagne? The U.K.'s wine industry is an unlikely winner as its European peers reel from extreme weather', *Fortune*, November 12, 2023. Retrived in April 2024 from: http://fortune.comnditee/2023/11/12/climate-change-uk-britain-wine-industry-vineyard-europe-extreme-weather/

Queiroz, M. M., S. Fosso Wamba, R. D. Raut and I. O. Pappas (2023). 'Does resilience matter for supply chain performance in disruptive crises with scarce resources?' *British Journal of Management*, **35**, pp. 974–991. https://doi.org/10.1111/1467-8551.12748.

Ratten, V. (2022). 'The Ukraine/Russia conflict: geopolitical and international business strategies', *Thunderbird International Business Review*, **65**, pp. 265–271.

Reimann, M., U. F. Lünemann and R. B. Chase (2008). 'Uncertainty avoidance as a moderator of the relationship between perceived service quality and customer satisfaction', *Journal of Service Research*, **11**, pp. 63–73.

Robbins, S. P. and T. A. Judge (2010). *Organizational behavior 14th edition*. Peason College Div.

Safaya, S. (2023). 'Inditex smashes year-end results, praises business model', *Just Style*, March 2023. Retrived in April 2024 from: http://www.just-style.com/newsnditexx-smashes-year-end-results-praises-business-model/?cf-view.

Sardana, D., N. Gupta, V. Kumar and M. Terziovski (2020). 'CSR "sustainability" practices and firm performance in an emerging economy', *Journal of Cleaner Production*, **258**, p. 120766.

Schneider, A., C. Wickert and E. Marti (2017). 'Reducing complexity by creating complexity: a systems theory perspective on how organizations respond to their environments', *Journal of Management Studies*, **54**, pp. 182–208.

Schwens, C., F. B. Zapkau, K. D. Brouthers and L. Hollender (2018). 'Limits to international entry mode learning in SMEs', *Journal of International Business Studies*, **49**, pp. 809–831.

Smith, W. (2001). 'Chaos theory and postmodern organization', *International Journal of Organization Theory and Behavior*, **4**, pp. 259–286.

Summerfield, M. (2023). 'Future climate and the impact on wine: Predictable or uncertain?', *The world of Fine Wine*, August 2023. Retrieved from: https://worldoffinewine.com/news-features/climate-change-impact-wine.

Tambe, P., P. Cappelli and V. Yakubovich (2019). 'Artificial intelligence in human resources management: challenges and a path forward', *California Management Review*, **61**, pp. 15–42.

Tarba, S. Y., J. G. Frynas, Y. Liu, G. Wood, R. M. Sarala and S. Fainshmidt (2023). 'Strategic agility in international business', *Journal of World Business*, **58**, p. 101411.

Teece, D. J. (2020). 'Fundamental issues in strategy: Time to reassess?', *Strategic Management Review*, **1**, pp. 103–144.

The Economist. (2019). 'Climate change is forcing winemakers to move further from the equator', *The Economist*, November 22, 2019. Retrived in April 2024 from: https://www.economist.com/graphic-detail/2019/11/22/climate-change-is-forcing-winemakers-to-move-further-from-the-equator

Vaillant, Y. and E. Lafuente (2019). 'The increased international propensity of serial entrepreneurs demonstrating ambidextrous strategic agility: a precursor to international marketing agility', *International Marketing Review*, **36**, pp. 239–259.

Vincent, S., G. J. Bamber, R. Delbridge, V. Doellgast, J. Grady and I. Grugulis (2020). 'Situating human resource management in the political economy: multilevel theorising and opportunities for kaleidoscopic imagination', *Human Resource Management Journal*, **30**, pp. 461–477.

Volberda, H. W., C. Baden-Fuller and F. A. J. van den Bosch (2001). 'Mastering strategic renewal: mobilising renewal journeys in multi-unit firms', *Long Range Planning*, **34**, pp. 159–178.

Vorhies, D. W. (1998). 'An investigation of the factors leading to the development of marketing capabilities and organizational effectiveness', *Journal of Strategic Marketing*, **6**, pp. 3–23.

Wamba, S. F., M. M. Queiroz, C. J. C. Jabbour and C. V. Shi (2023). 'Are both generative AI and ChatGPT game changers for 21st-Century

operations and supply chain excellence?', *International Journal of Production Economics*, **265**, p. 109015.
Wang, P., E. Y. Xing, X. Zhang and Y. Liu (2022). 'Sensemaking and sustainable development: Chinese overseas acquisitions and the globalisation of traditional Chinese medicine', *Global Policy*, **13**, pp. 23–33.
Warner, K. S. R. and M. Wäger (2019). 'Building dynamic capabilities for digital transformation: an ongoing process of strategic renewal', *Long Range Planning*, **52**, pp. 326–349.
Weber, Y. and S. Y. Tarba (2014). 'Strategic agility: a state of the art introduction to the special section on strategic agility', *California Management Review*, **56**, pp. 5–12.
Wheatley, M. J. (1994). 'Can the US Army become a learning organization?', *The Journal for Quality and Participation*, **17**, p. 50.
Whittington, R. (1990). 'Social structures and resistance to strategic change: British manufacturers in the 1980s', *British Journal of Management*, **1**, pp. 201–213.
Wilkinson, I. and L. Young (2002). 'On cooperating: firms, relations and networks', *Journal of Business Research*, **55**, pp. 123–132.
Xing, Y. (2016). 'A Daoist reflection on sea-like leadership and enlightened thinking', *Management and Organization Review*, **12**, pp. 807–810.
Xing, Y. and D. Sims (2016). 'Leadership, Daoist Wu Wei and reflexivity: flow, self-protection and excuse in Chinese bank managers' leadership practice', *Management Learning*, **43**, pp. 97–112.
Xing, Y. and M. Starik (2017). 'Taoist leadership and employee green behaviour: a cultural and philosophical microfoundation of sustainability', *Journal of Organizational Behavior*, **38**, pp. 1302–1319.
Yang, I. (2015). 'Positive effects of laissez-faire leadership: conceptual exploration', *Journal of Management Development*, **34**, pp. 1246–1261.
Zhang, X., Y. Liu, S. Y. Tarba and M. d. Giudice (2020). 'The microfoundations of strategic ambidexterity: Chinese cross-border M&As, mid-view thinking and integration management', *International Business Review*, **29**, p. 101710.
Zhou, Y., Y. Cheng, Y. Zou and G. Liu (2021). 'e-HRM: a meta-analysis of the antecedents, consequences, and cross-national moderators', *Human Resource Management Review*, **32**, p. 100862.

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Supporting Information

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