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ORIGINAL EMPIRICAL RESEARCH

Organizational learning and technological innovation: the distinct dimensions of novelty and meaningfulness that impact firm performance

Li Zuo[1] · Gregory J. Fisher[2] · Zhi Yang[3]

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Abstract
This manuscript delineates technological innovation into the separate dimensions of novelty and meaningfulness to examine how a firm's organizational learning modes of adaptive learning and experimental learning, together with unabsorbed slack resources, influence the effects of novelty and meaningfulness on firm financial performance. The multi-method empirical approach leverages secondary data from firm patent information and COMPUSTAT, and primary data from senior executives at 167 firms in various high-tech industries. The results indicate that adaptive learning heightens meaningfulness but diminishes novelty, whereas experimental learning harms meaningfulness. Additionally, firms' unabsorbed slack resources moderate the relationships of experimental and adaptive learning with novelty. In particular, experimental learning enhances novelty only when a firm has sufficient unabsorbed slack to adjust resource levels in accordance with experimentation. Further, the results suggest that meaningfulness increases firm financial performance as represented by Tobin's q, both independently and jointly when considered with novelty. These insights underscore the necessity of treating novelty and meaningfulness as separate dimensions of technological innovation that impact firm performance.

Keywords Experimental learning · Adaptive learning · Slack resources · Innovation novelty · Innovation meaningfulness · Shareholder value · Organizational learning · Firm performance

Introduction

Generating innovation is an ongoing aspiration of firms (Arnold et al. 2011; Chandy and Tellis 1998) that especially challenges technology-focused companies (Mohr and Sarin 2009), since technological innovation provides a basis for new products that create value for firms (Garcia and Calantone 2002). Extant studies in marketing strategy investigate the numerous drivers of innovation, including organizational learning (Moorman and Miner 1997), marketing orientation (Han et al. 1998), and demand-side inertia effects (Stanko et al. 2013), as well as the impact of innovation on firm performance and competitive advantage (Hauser et al. 2006).

Despite such prior research, several gaps remain. First, various terms describe aspects of technological innovation (Garcia and Calantone 2002) that conflict, create ambiguity, and hinder formation of effective marketing strategy. Two specific elements of technological innovation, novelty and meaningfulness, are often treated as congruent, though this conjecture is inaccurate. Innovation novelty reflects newness and unique differences from existing ideas (Ahuja and Lampert 2001; Chandy et al. 2006), while meaningfulness captures the impact of innovation on the market and future innovation developments (Gatignon and Xuereb 1997; Im and Workman 2004). This distinction matters for marketing

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✉ Zhi Yang
yangmkt@126.com

Li Zuo
lzuo@bjtu.edu.cn

Gregory J. Fisher
fishergj@MiamiOH.edu

1 School of Economics and Management, Beijing Jiaotong University, Beijing, China

2 Farmer School of Business, Miami University, 800 E. High Street, Oxford, OH 45056, USA

3 School of Business Administration, Hunan University, Changsha, Hunan Province, China

managers because novelty and meaningfulness offer different paths for guiding marketing strategy. The meaningfulness dimension provides direct value to the marketplace, which is a focal outcome pursued by marketers. Conversely, while novelty is not always immediately recognized as valuable by customers, novelty interests marketing managers because the novelty of technological innovation increases the difficulty of imitation and substitutability by competitors. This manuscript unpacks the dimensions of meaningfulness and novelty to parcel out their distinct contributions to firm performance.

Second, while marketing scholars identify different types of organizational learning as necessary for innovation (Baker and Sinkula 1999; Hurley and Hult 1998), firms struggle with knowing when each approach is warranted. Although organizational learning is recognized as an important antecedent to innovation (Weerawardena et al. 2015), prior studies diverge when recommending its strategic implementation. Some scholars advocate experimental learning in which the firm engages in trial-and-error iterations to gain insight into technological areas (Day 2014; Zollo and Winter 2002). Yet others recommend adaptive learning, whereby firms react to the environment and focus technology development in specific areas to fit contextual conditions (Tyre and von Hippel 1997; Zhou et al. 2005). This manuscript builds on the organizational learning literature by delineating experimental and adaptive as specific learning modes and by examining their differing effects on technological innovation novelty and meaningfulness.

Third, the organizational learning literature highlights the role of slack resources as an important influence that can complement or impede innovation (Argote 2012; McGrath 2001). In particular, unabsorbed slack resources are relevant to this area because they are accessible and can be deployed by managers to affect innovation (Tan and Peng 2003). However, it is unclear how such slack moderates the relationships of experimental and adaptive learning with novelty and meaningfulness, as prior studies offer conflicting views about slack and innovation (Nohria and Gulati 1996). Some research finds that slack positively influences innovation and financial performance because it permits flexibility to work on ideas that might not be developed in more resource-constrained environments (Josephson et al. 2016). Yet at times, slack encourages a false sense of security that incentivizes employees to work on wasteful endeavors instead of pursuing innovation that leads to added value for the market (Nohria and Gulati 1996). In a meta-analysis of research on slack resources, Daniel et al. (2004) conclude that further research is needed to understand the effects of slack on firm performance in different strategic contexts.

This manuscript addresses these gaps by answering the following questions: (1) What are the effects of experimental learning and adaptive learning on the novelty and meaningfulness dimensions of technological innovation? (2) How are these effects contingent upon a firm's unabsorbed slack resources? (3) How do novelty and meaningfulness impact the firm's financial performance? This research takes a multimethod approach by collecting secondary data from COMPUSTAT and firm patents, and primary data from executives in 167 high-tech firms. The results show that adaptive learning heightens meaningfulness but diminishes novelty, whereas experimental learning hinders meaningfulness. Also, a firm's unabsorbed slack resources moderate the relationships of learning with novelty. In particular, experimental learning enhances novelty only when a firm has sufficient unabsorbed slack and, thus, the flexibility to vary resource levels in concert with experimentation. Finally, the results suggest meaningfulness increases firm shareholder value both independently and jointly when considered with novelty.

This manuscript offers several contributions. First, it highlights the need and importance of considering technological innovation in the marketing literature, whereas extant research in this domain tends to give more attention to product innovation (e.g., Szymanski et al. 2007). For example, a meta-analysis studying antecedents of product innovation identifies dimensions of innovation performance such as market share, sales, return on assets and investment, and profit (De Luca and Atuahene-Gima 2007). While those aspects of product innovation are certainly important, marketing managers and scholars can benefit from further study of technological innovation, which provides a foundation for products that solve unmet market needs to garner such performance outcomes. In particular, marketers are concerned with solutions that are valued by customers and provide differentiation from competitive offerings. Our research suggests that technological innovation holds the potential to convey such benefits.

Second, this research shows the importance of identifying novelty and meaningfulness as separate facets of technological innovation that ensue from different learning mechanisms. Notably, experimental learning frequently is considered to be a fundamental activity for generating innovation due to its penchant for risk taking and trying out new ideas (Slater and Narver 2000). However, we find that experimental learning, when isolated, does not have a significant effect on novelty, and actually has a detrimental effect on meaningfulness. In contrast, extant research has found negative outcomes associated with adaptive learning since it may bias the firm against new ideas, cause reluctance to pursue unfamiliar knowledge areas, discourage risk-taking, and misestimate potential opportunities on the basis of small samples (Denrell and March 2001). By distinguishing novelty and meaningfulness, our results suggest that adaptive learning serves to increase meaningfulness, while having a negative effect on novelty. Thus, it is critical to delineate these two organizational learning approaches to reveal their divergent influences on the distinct dimensions of novelty and meaningfulness.

Third, this paper clarifies the relationship between a firm's unabsorbed slack resources and technological innovation. Proponents of organizational slack assert that unabsorbed slack is beneficial for providing a discretionary buffer for firms to pursue undefined opportunities and allow ideas to be developed in the face of uncertainty. Detractors argue that surplus resources invite inefficiency, waste, and the pursuit of projects with unnecessary costs (Daniel et al. 2004). Our research explains such inconsistencies as follows. Experimental learning alone is insufficient for garnering novelty; rather, firms should provide unabsorbed slack resources in conjunction with experimental learning activities to spur novelty. Yet we also find that unabsorbed slack exacerbates the negative effect of adaptive learning on novelty. Thus, when coupled with the appropriate learning mechanism, unabsorbed slack can benefit firms and help them avoid the negative costs that often are attributed to surplus resources. Consequently, our research offers a more nuanced view that the influence of unabsorbed slack depends on the context of learning and the separate examination of novelty and meaningfulness.

Fourth, this research establishes empirical linkages between novelty, meaningfulness, and firm financial value. It is critical to study these attributes separately because meaningfulness is a distinct dimension of innovation that is tied to stronger performance than considering novelty alone (Szymanski et al. 2007). Our results suggest that meaningfulness increases shareholder value, both independently and jointly when considered with novelty.

In summary, our research extends the literature on organizational learning by isolating experimental and adaptive learning and their effects on technological innovation novelty and meaningfulness to identify specific conditions when unabsorbed slack may moderate these relationships, and to connect those effects to the resulting impact on firm financial performance.

Conceptual framework

Technological innovation: Novelty and meaningfulness

Technological innovation provides a key foundation for a firm's new product development activities that seek to produce solutions to unmet market needs (Garcia and Calantone 2002). Prior research has noted the importance of understanding technological innovation's role in driving positive outcomes for firms and their customers (Sood and Tellis 2005). Frequently, scholars have focused on the newness of such innovation to explain why incumbent firms decline while other firms rise to success (Hill and Rothaermel 2003). With regard to the newness aspect of innovation, Chandy and Tellis (1998) submit that firms who leverage technology that is substantially different than existing technology hold the potential to disrupt competitors by fulfilling customer needs better than established solutions. In such contexts, technological innovation is often defined in terms of its degree of novelty, which is identified by its difference from established knowledge bases (Cardinal 2001; Hill and Rothaermel 2003).

While novelty has long been an important factor of research on technological innovation, recent studies parcel out a distinct dimension that reflects meaningfulness (Stock and Reiferscheid 2014). Meaningfulness considers the extent to which innovation is useful to customers and important as an input for future innovations. Technological innovations that are valued by the market tend to influence subsequent innovation activities because their value is recognized by customers. This usefulness is exhibited through distinct benefits and value that is provided to current and future customers (Stock and Zacharias 2011). In contrast, novelty refers to the extent to which a firm's technological innovation differs from existing technologies within a given domain. Thus, whereas novelty is a backward-looking concept that focuses on newness in comparison with existing knowledge domains, meaningfulness is a forward-looking notion that reflects the future impact on customers and further innovation development. Consequently, this research delineates technological innovation into the two critical dimensions of novelty and meaningfulness. Table 1 offers definitions of focal constructs and references.

Organizational learning: Experimental and adaptive learning

Organizational learning is a process that underpins a firm's accumulation, generation, and utilization of knowledge (Bell et al. 2002), which provides a foundation for a firm to improve its financial performance (Vorhies et al. 2011). According to organizational learning theory, a firm's ability to process knowledge is crucial for innovation (Cohen and Levinthal 1990). In particular, adaptive learning and experimental learning represent two key modes of organizational learning that can affect innovation.

First, *adaptive learning* refers to the degree to which a firm scans the environment and adjusts the focus of its technology development activities to fit contextual conditions (Baker and Sinkula 1999; Kitchell 1995). A firm can adapt its learning by integrating external insights into its innovation efforts and by adjusting its innovation activities with contingency plans for potential market changes (Chakravarthy 1982). In other words, adaptive learning concentrates the firm's knowledge development on a frame of reference in a specific area. An organization that engages in adaptive learning analyzes the environment in which it is situated to consider the options that are available and responds to this information through innovation (Tyre and von Hippel 1997). With adaptive learning, a firm senses emerging opportunities and responds accordingly with its innovation activities (Sinkula 1994). Hence, adaptive learning is reactive in the sense that it tends to employ a more

Table 1 Definitions and operationalizations

Constructs	Definitions	Example references	Measurements	Data source
Innovation novelty	Extent that a firm's technological innovation exhibits unique differences and newness from existing ideas	Ahuja and Lampert 2001; Chandy et al. 2006	Average number of backward citations for granted patents from 1999 to 2003 (reverse coded)	Delphion Patent Database
Innovation meaningfulness	Importance of a firm's technological innovation for future innovation developments	Chandy et al. 2006; Im and Workman 2004	Average number of annual forward citations for granted patents from 1999 to 2003	Delphion Patent Database
Innovation stock	Available patent assets	Hall et al. 2001	Log transformation of number of granted patents from 1999 to 2003	Delphion Patent Database
Experimental learning	Degree that a firm engages in iterative trial-and-error processes to understand innovation knowledge in unfamiliar domains	Crossan and Berdrow 2003; Levitt and March 1988	Newly developed measures; see Appendix	Primary Survey
Adaptive learning	Degree that a firm scans the environment (e.g., for information, technology) and adjusts and focuses its activities in response	Baker and Sinkula 1999; Kitchell 1995	Newly developed measures; see Appendix	Primary Survey
Environmental dynamism	Degree of unpredictability and change in a market environment	Fang et al. 2008a	Adapted from Jaworski and Kohli (1993)	Primary Survey
Unabsorbed slack resources	Excess firm resources that are easily deployable to support innovation activities	Nohria and Gulati 1996; Singh 1986	Average of retained earnings / total assets from 1999 to 2003	COMPUSTAT
R&D intensity	Firm R&D spending	Matzler et al. 2015; Prabhu et al. 2005	Average of R&D expenditures / sales revenue from 1999 to 2003	COMPUSTAT
Firm size	Firm employment	Ahuja and Lampert 2001	Log transformation of number of employees (2004)	COMPUSTAT
Shareholder value	Relationship of the stock market valuation of the firm to its total assets	Lee and Grewal 2004; Srinivasan 2006	Tobin's q (2004)	COMPUSTAT

focused trajectory of knowledge development that is grounded in changes that occur in the firm's environment.

Second, *experimental learning* is the degree to which an organization engages in iterative trial-and-error knowledge development processes to understand and innovate in less familiar domains (Levitt and March 1988). Experimentation is motivated by the goal of achieving insights into emerging technologies and gaining access to technological areas (Slater and Narver 2000). To achieve these insights, experimentation requires a process of trial ➔ failure ➔ learning ➔ correction ➔ retrial (Moorman and Miner 1998a) and a learning-by-doing mechanism to support innovation activities (Huber 1991). This process encourages the firm to participate in a potentially broader trajectory of knowledge development that is associated with expected occurrences of failure and retrial. As a result, experimental learning tends to be more proactive in that it forces the organization to learn new competencies that may not be based upon recognized changes in the firm's environment.

Adaptive learning and experimental learning are organization-level constructs that differ from the related concepts of exploration and exploitation, which are often depicted at the project level in the organizational learning literature (e.g., Brady and Davies 2004). For example, Huang and Li (2012) describe exploitative learning as the reuse and refinement of existing knowledge for specific project performance improvements such as new product development efficiency and speed of market entry. Other scholars discuss that exploitative learning develops knowledge about the firm's existing products and markets (Vorhies et al. 2011). With regard to technological innovation in particular, exploitation is depicted as building upon existing technology to improve existing product and market domains (Gupta et al. 2006). However, adaptive learning does not necessarily rely upon existing knowledge of products and markets. Rather, it is a reactive approach that the firm uses to adjust its learning activities to fit the emergence of threats and opportunities. Adaptive learning allows the firm to alter its own internal knowledge sets and thus learn within a specific frame of reference (Huber 1991). In other words, while exploitative learning emphasizes the application of existing knowledge to specific projects and products, adaptive learning emphasizes the organization's adjustment to focus its learning activities in response to contextual conditions.

Similarly, exploratory learning is often described in a project context in the organizational learning literature, such as the acquisition of new knowledge and the use of different perspectives to stimulate new product ideas and to achieve more efficient new product development (Huang and Li 2012). The emphasis of exploration is on the identification and application of knowledge that is new to the firm (Vorhies et al. 2011). However, some scholars note that mindfully scanning for new knowledge often conflicts with a firm's willingness to experiment (Day 2014). Conversely, experimentation emphasizes learning-by-doing such that the organization focuses on learning from failures and risk-taking (Levitt and March 1988). Thus, experimental learning is a proactive learning mechanism by which the firm attempts various trial-and-error processes before opportunities emerge in the environment (Zollo and Winter 2002). While exploratory learning focuses on the acquisition and use of new knowledge, experimental learning stresses learning through iterative trial-and-error activities.

The concepts of adaptive and experimental learning are strategic firm choices that are neither mutually exclusive nor interchangeable with the concepts of exploitative and exploratory learning. For example, Posen and Levinthal (2012) note that a firm can adaptively learn by generating new knowledge. When discussing how firms adapt their learning, they surmise that "the appropriate response to environmental change is not necessarily a strategic shift of effort toward exploration – indeed, a shift toward exploitation is sometimes superior" (Posen and Levinthal 2012, p. 588). Other organizational learning scholars note that experimental learning may occur irrespective of a firm's subsequent choice to pursue exploratory learning or exploitative learning, as summarized by the following example, "an engineer might search and experiment to discover a new method of producing a product, but the organization in which he/she is employed might then exploit this new innovation for profit" (Gupta et a. 2006, p. 695). In other words, a firm's adaptive learning and experimental learning occur at a relatively fundamental level, while the choice of exploration or exploitation often occurs in reference to a particular project or outcome. In our research, we focus on differences in adaptive learning and experimental learning, and their influences on technological innovation and firm financial performance. The divergent effects of experimental and adaptive learning on novelty and meaningfulness are discussed below. Figure 1 depicts the conceptual model and hypotheses.

Connecting organizational learning with novelty and meaningfulness

First, we consider the effects of experimental learning. The generation of novelty demands that organizations constantly challenge their long-held assumptions about technology development (Sethi et al. 2001). Novelty requires firms to deviate from their comfortable domain of expertise by incorporating new perspectives and ideas into their innovation efforts (Ahuja and Lampert 2001). Experimental learning moves the firm away from its established competencies (Huber 1991) and facilitates the firm's ability to improvise its innovation behaviors and gain new perspectives in unfamiliar knowledge areas. As Moorman and Miner (1998a) note, experimental learning provides an important approach to evaluate different methods, techniques, languages, and tools, with the potential to add novel knowledge to organizational

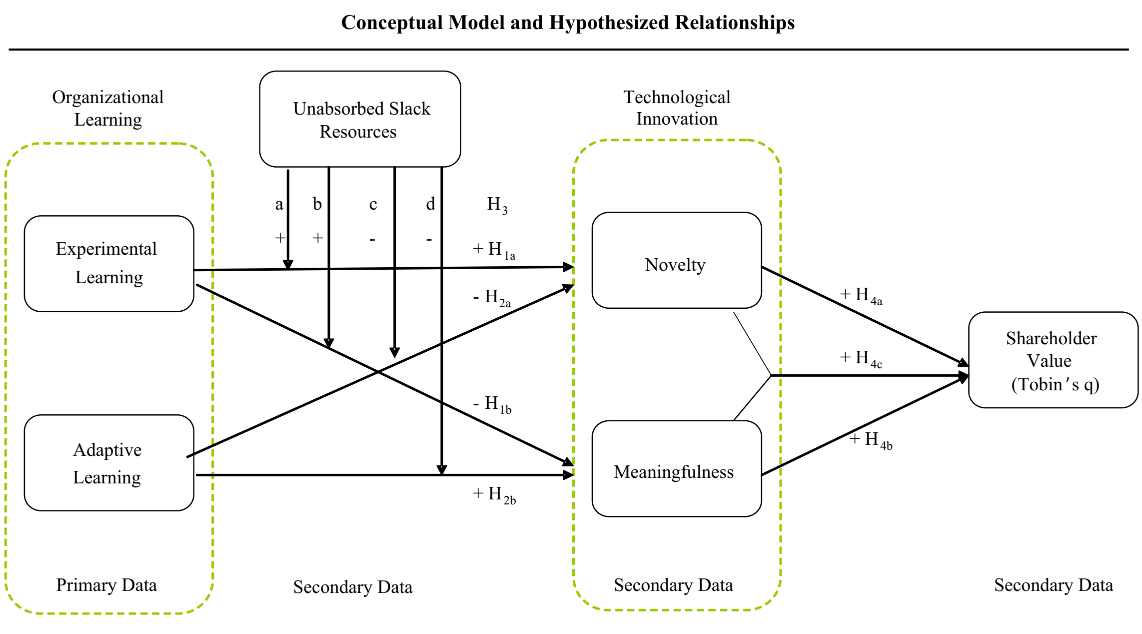

Fig. 1 Conceptual model and hypothesized relationships

memory. Further, by permitting mistakes, experimental learning provides technology developers with more flexibility to develop new competencies in unfamiliar areas and accepts more risk in the pursuit of unique innovation opportunities. Such risk-taking attempts are crucial for developing novel technologies whose outcomes are often uncertain (Chandy and Tellis 1998; Levinthal and March 1993).

However, experimental learning tends to be broader and requires a firm to try unfamiliar tools, methods, and cognitive styles. The uncertainty associated with experimental trial-and-error learning creates hurdles to understanding knowledge relationships in narrow technological domains (Zahra and George 2002). An overemphasis on experimentation may cause the organization to look past opportunities when such trial-and-error learning is not connected to fulfilling needs identified in the external environment (Levinthal and March 1993). Experimental learning may divert the firm away from knowledge accumulation and development of a critical mass in specific areas that are necessary to advance ideas that have high potential for additional market breakthroughs (Zhao 2006). Consequently, experimental learning is linked to low meaningfulness if the experimentation is not connected to fulfilling needs that the external marketplace defines as valuable. Therefore, we hypothesize that:

H1: A firm's experimental learning (a) positively influences novelty but (b) negatively influences meaningfulness.

In contrast, our framework predicts that adaptive learning has opposite relationships with novelty and meaningfulness. Adaptive learning supports the pursuit of meaningful technologies by aligning the organization's knowledge activities with external, emerging opportunities. Pursuit of specific technology opportunities influences the firm's accumulation of knowledge in narrow areas, reinforces biases in favor of reproducible results, and influences the firm to seek further learning within a specific domain (Denrell and March 2001). A focus on known technology opportunities motivates the firm to concentrate its knowledge competencies in areas that should have greater impacts on meaningful innovation development (Zhou et al. 2005). This focus prompts the firm to adjust its technology activities to meet changing market needs that are identified through the firm's adaptive learning approach, which encourages the use of knowledge competencies in response to external conditions. As a result, the organization uses its accumulated knowledge to understand and seize such external opportunities (Argyris and Schon 1978). As the firm responds to areas valued by the environment, adaptive learning encourages meaningful knowledge activities that have greater impacts on future innovation development.

However, adaptive learning is disadvantageous for novelty. Because it reacts to emerging opportunities, adaptive learning tends to engage in focused search (Huber 1991). That is, the firm searches narrowly for solutions to specific opportunities identified in its environment. Thus, "the resulting learning boundary … constrains organizational learning to the adaptive variety, which usually is sequential, and focused on issues or opportunities that are within the traditional scope of the organization's activities" (Slater and Narver 1995, p. 68). The sequential sampling approach of adaptive learning biases firms against unfamiliar technologies and constrains them from seeking distant knowledge (Denrell and March 2001). Firms that are highly proficient with a narrow technology trajectory often encounter difficulty with pursuing unfamiliar routines and technologies, a dilemma that is referred to as the "competency trap" (Levinthal and March 1993). In other words, adaptive learning makes the firm prefer innovation activities that meet known opportunities, which tends to minimize novelty. Therefore, we hypothesize that:

H2: A firm's adaptive learning (a) negatively influences novelty but (b) positively influences meaningfulness.

Moderating role of unabsorbed slack resources

While experimental and adaptive learning are associated with technological innovation, strategic influences managed by the firm significantly affect these mechanisms (Nonaka 1994). One specific strategic influence, slack resources, holds particular importance for organizational learning and innovation (Nohria and Gulati 1996). Our research focuses on *unabsorbed slack resources* because unabsorbed slack is highlighted by literature examining the influence of slack on innovation (Subramanian and Nilakanta 1996; O'Brien and David 2014). Unabsorbed slack entails excess resources that are "more easily deployable in support of innovation activity" (Nohria and Gulati 1996, p. 1247) compared to absorbed slack, which is already committed within the organization (Singh 1986). In other words, unabsorbed slack is more easily accessible for innovation activities than absorbed slack (O'Brien and David 2014; Tan and Peng 2003).

Unabsorbed slack is complementary when the firm is engaged in experimental learning because it offers "excess, uncommitted liquid resources" (Singh 1986, p. 567) that can be allocated to various technology alternatives. For experimental learning, a high level of unabsorbed slack resources "allow [the] pursuit of risky innovative projects because it protects [the organization] from uncertain success of those projects," and thus facilitates a culture of experimentation (Nohria and Gulati 1996, p.1247). As a result, unabsorbed slack accommodates greater managerial discretion to choose among potential innovation paths (Tan and Peng 2003). Additionally, unabsorbed slack plays a vital role in resolving internal conflicts among R&D developers who compete for limited resources when attempting to advance novel technologies (Bourgeois 1981). Thus, our conceptual framework proposes unabsorbed slack resources as a positive moderator affecting experimental learning's relationship with novelty.

Similarly, unabsorbed slack resources can have a beneficial influence on experimental learning's effect on meaningfulness. The uncertainty and variability associated with experimental learning makes it difficult to gauge *ex ante* a sufficient level of resources required to garner meaningful technological innovation. When coupled with experimental learning, unabsorbed slack provides the firm with flexibility to pursue projects that may not appear justifiable from the perspective of strict internal financial controls but may hold high potential to impact future developments (Tan and Peng 2003). Creating meaningful technological innovation via experimental learning requires a long-term perspective that affords developers the patience needed to test ideas and prototypes. Unabsorbed slack allows the firm more latitude to adjust resource levels as experimentation progresses (Huang and Li 2012). Thus, unabsorbed slack serves to attenuate the negative effect of experimental learning on meaningfulness.

However, unabsorbed slack resources may negatively influence adaptive learning's effects on novelty and meaningfulness. Unabsorbed slack provides excess internal resources that promote wasteful behavior by adaptive learners (Nohria and Guliati 1996). The presence of unabsorbed slack diminishes discipline and control over innovation projects while creating inefficiencies that self-reinforce the firm's technological efforts (Wu and Tu 2007). Frequently, this leads to an organizational rigidities paradox in which the adaptive firm becomes comfortable with a known area to the extent that the deeply embedded knowledge creates obstacles for novelty (Leonard-Barton 1992). In other words, unabsorbed slack resources may worsen adaptive learning's effect on novelty.

Moreover, unabsorbed slack resources can be detrimental to adaptive learning's positive effects on meaningfulness. Unabsorbed slack can breed complacency within an adaptive firm by discouraging sensitivity to changes in the external environment (Nohria and Gulati 1996). Cheng and Kesner (1997, p. 3) argue that firms use slack resources "to buffer environmental influences" such that "the presence of slack might actually reduce a firm's aggressiveness in responding to environmental shifts." The disincentive to aggressively respond to external changes encourages self-satisfaction, which can become a prevalent cultural value within the firm that is susceptible to the organizational rigidities paradox (Leonard-Barton 1992). Such rigidities discourage the firm from adjusting to subsequent environmental changes and often lead to less valuable future innovations (Morgan 2012). By reducing the adaptive organization's sensitivity toward external change, unabsorbed slack serves to weaken adaptive learning's effect on meaningfulness. Thus, we hypothesize that:

H3: The moderating effect of unabsorbed slack resources (a) intensifies the positive effect of experimental learning on novelty, (b) attenuates the negative effect of experimental learning on meaningfulness, (c) intensifies the negative effect of adaptive learning on novelty, and (d) attenuates the positive effect of adaptive learning on meaningfulness.

Novelty, meaningfulness, and firm financial performance

The organizational learning literature suggests that firms' innovation directly contributes to their competitive advantage and financial value (Amit and Schoemaker 1993; Bell et al.

2002). An important indicator of firm financial performance is shareholder value (Tobin's q), which is the relationship of the stock market valuation of the firm to its total assets (Lee and Grewal 2004). As critical dimensions of technological innovation, both novelty and meaningfulness can significantly enhance shareholder value. Novelty provides value to the firm by offering differentiation, which increases the difficulty of imitation and substitutability by competitors (Wuyts et al. 2004). In contrast, meaningfulness heightens the value of a firm's technological innovation by being appropriate and useful for customers (Im and Workman 2004).

In addition to their independent effects on shareholder value, these two dimensions may interact to jointly enhance shareholder value. Some technological innovation achieves the effect of being both novel and meaningful as inputs for new product outcomes. For example, the original Apple iPhone was quite different from existing cellphones yet was also very impactful for future innovations in the cellphone category. While not all technological innovation excels at both novelty and meaningfulness, researchers suppose that innovations that incorporate both dimensions are able to more strongly affect firm performance (Szymanski et al. 2007). We share this perspective that novelty may synergistically increase the effect of meaningfulness (Nakata et al. 2018). When the novelty of a technological innovation seems unfamiliar to the market, then the meaningfulness of the same innovation can help the market to recognize the importance, usefulness, and potential value of its novelty. Similarly, the firm can better leverage meaningful, high-impact technological innovation to enhance shareholder value by protecting and sustaining its competitive position with the novelty of such innovation. Novelty exhibits unique differences from existing ideas (Ahuja and Lampert 2001; Chandy et al. 2006), and such uniqueness makes it more difficult for competitors to imitate the firm's innovation. Consequently, since some technological innovation exhibits both novelty and meaningfulness, we consider the joint effects of these dimensions on firm performance. Thus, we hypothesize that:

H4: A firm's technological innovation (a) novelty and (b) meaningfulness, as well as (c) the interaction of novelty and meaningfulness, have positive effects on shareholder value.

Empirical methodology

Our data sources include archival data about firm patents, COMPUSTAT, and a primary survey of senior executives. All firms in the sampling frame were drawn from high-tech industries such as computers and related products (standard industrial classification [SIC] codes 3571–3577), electronic equipment (SIC 3600), semiconductors (SIC 3674), computer processing (SIC 7374), and pharmaceuticals (SIC 2834). High-tech industries are frequently selected for the study of innovation and firm performance (e.g., Slater et al. 2007; Szymanski et al. 2007). In high-tech industries, technological innovation is a key means to ensure long-term firm performance and competitive advantage. Moreover, firms tend to rely on patents to protect their innovations as intellectual property (Jaffe and Trajtenberg 2002). The COMPUSTAT and Delphion databases provide complete data for 752 firms regarding technological innovation novelty and meaningfulness, Tobin's q, unabsorbed slack resources, firm size, and R&D intensity. Table 1 describes the variables, measurements, and sources of data.

Secondary data

Novelty and meaningfulness Since a firm's technological innovation portfolio accumulates over time and involves knowledge across different domains, our research relies on secondary data about firm patents to measure novelty and meaningfulness. Patents serve as suitable proxies for intermediate innovation activities (Matzler et al. 2015; Prabhu et al. 2005), especially for firms in the sampled industries, which tend to codify their technological innovation as patents (Jaffe and Trajtenberg 2002). Market and regulatory mechanisms incent patents to be an objective measure. When applying for a patent, a firm is not induced to cite other patents unless it is necessary because citing other patents reduces the scope and claims of the firm's own patent. Meanwhile, patent examiners check that the new patent appropriately cites existing patents. Thus, there are opposing forces that encourage the patent to neither overstate nor understate its reliance upon codified knowledge (Bonaccorsi and Thoma 2007; Chandy et al. 2006). Following prior research (Chandy et al. 2006; Prabhu et al. 2005), this study utilizes the Thompson Scientific Delphion database, a comprehensive database that includes all U.S.-granted patents since 1964. Technological innovation portfolios consist of patents granted by the U.S. Patent and Trademark Office from 1999 to 2003. To construct the portfolios, any firms that possess too few granted patents (less than five) are deleted.

When a patent is granted, a public document is created that contains two types of citations: backward and forward. Backward citations refer to previous patents on which the granted patent builds and, thus, represent the extent to which the granted patent makes a novel contribution beyond the prior state of knowledge (Jaffe and Trajtenberg 2002). Few or no backward citations indicates a lower reliance on existing knowledge. Instead, such patents suggest a departure from existing patents to create new knowledge (i.e, higher novelty). In contrast, numerous backward citations suggest a trail of knowledge spillovers flowing from prior patents (Bonaccorsi and Thoma 2007) such that the granted patent relies more heavily on existing innovation knowledge (i.e., lower novelty) (Chandy et al. 2006).

This conceptualization and measure of novelty is different from patent originality. In existing research that utilizes patents, originality is based on the premise that a patent that cites a wide range of divergent ideas is characteristic of research that is highly original (Hall et al. 2001). While building upon numerous existing patents can yield original solutions, researchers suggest that building ideas within existing patented domains may constrain the invention of novel solutions that are unprecedented and break away from prevailing knowledge (Ahuja and Lampert 2001). Further, backward citations represent an important means to protect firms from intellectual property infringement allegations, so utilizing backward citations as a measure of novelty seems particularly appropriate (Jaffe and Trajtenberg 2002). Consistent with prior studies (e.g., Chandy et al. 2006), this research uses the average number of backward citations in a firm's patent portfolio as a reverse-coded measure of novelty.

Forward citations, in contrast, indicate the number of future patents that cite an existing focal patent. Forward citations are frequently used by researchers to measure the importance of ideas that are codified in the form of patents (Chandrasekaran and Tellis 2011; Chandy et al. 2006), the patents' economic value (Matzler et al. 2015; Reitzig 2003), and the patents' usefulness due to high correlations with industry awards, expert opinions, and measures of social value (Fleming and Sorenson 2001). Since meaningfulness comprises the degree to which a firm's technological innovation affects future innovation development, the number of forward citations in a firm's patent portfolio represents a valid proxy (Jaffe and Trajtenberg 2002). Our empirical modeling approach accounts for the time truncation issue associated with forward citations as follows. An older patent tends to be cited more often than a more recent patent because the older patent has more time to be cited. To address this issue, we calculated the annual number of forward citations after the patent is granted and average the annual forward citations across a firm's patent portfolio to obtain a measure of meaningfulness.

Shareholder value Consistent with previous studies (Lee and Grewal 2004; Srinivasan 2006), this research uses Tobin's q as a measure of shareholder value. Tobin's q is a forward-looking measure based on stock market prices that reflects future performance and a firm's long-term profitability (Lee and Grewal 2004). Moreover, Tobin's q is "risk adjusted, independent of industry, and provides a good indicator of shareholder value" (Morgan and Rego 2006, p. 427). This research employs Chung and Pruitt's (1994) method to calculate Tobin's q:

$$q = \frac{MVE + PS + DEBT}{TA}$$

where MVE is the closing price of shares at the end of the financial year × number of common shares outstanding, PS is the liquidation value of outstanding preferred stock, DEBT equals (current liabilities – current assets) + (book value of inventories) + (long-term debt), and TA is the book value of total assets. This study adopts a measure of Tobin's q for the year 2004.

Unabsorbed slack resources As suggested by Bourgeois (1981) and Tan and Peng (2003), this research uses the ratio of retained earnings to total assets to measure unabsorbed slack resources. Retained earnings reflect the resources that a firm elects to conserve as strategic options to allocate and deploy in a discretionary manner (Fang et al. 2008b). The ratio of retained earnings to total assets controls for the effects of firm size (i.e. total assets), such that larger firms need greater amounts of retained earnings. These data were obtained from COMPUSTAT between 1999 and 2003.

Primary survey data

Because the secondary data lack proxies for experimental learning and adaptive learning, we utilized a primary survey. This survey develops new measures of experimental and adaptive learning using the procedures recommended by Churchill (1979) and Gerbing and Anderson (1988). Initially, 10 interviews were conducted with executives from different high-tech firms. These interviews and an extensive review of previous studies were used to develop preliminary versions of the measurement scales. Subsequently, surveys were sent to a sample of 30 executives to verify the appropriateness of terminology and clarity of the instructions. In return, 11 questionnaires were received that indicated the survey instrument was generally sound, though a few items were modified for clarity.

Contact information was obtained from two commercial lists and company websites for all but 83 of the 752 organizations compiled in our archival data. Thus, the survey sampling frame consists of 669 firms. Each potential respondent was contacted by telephone and prequalified based upon their knowledge of their firm's learning activities. This approach follows prior researchers in the learning orientation domain who contend that organizational learning tends to be relatively stable and influences a firm's current performance (Baker and Sinkula 1999). As a result, 268 executives who met the prescreening criteria agreed to participate in the study. Each qualified executive received a cover letter and survey in 2003. After follow-up phone calls and a second distribution of the survey two weeks subsequent to the first, 182 responses were received. Respondent names and firms of completed surveys were matched to the contact information gathered in the secondary data. Responses were eliminated if the names and firms did not match the archival data, contained too many missing values (more than 5%), or indicated inadequate levels of knowledge and involvement in the firm's strategic decision processes (less than 4 on a 7-point scale). This approach yielded 167 usable responses. No significant differences exist between early and late respondents (Armstrong and Overton 1977). The respondents include senior vice presidents, vice presidents, senior marketing managers, project managers, and product managers.

For experimental learning, five items were created to measure the extent that the firm emphasizes and engages in experimentation and iterative trial-and-error learning processes to understand and develop technological knowledge even if the outcomes are uncertain. For adaptive learning, five items measure the extent that the firm scans the environment for potential opportunities, monitors the innovation activities of industry leaders, and adjusts its learning efforts accordingly. As shown in the Appendix, both measures provide acceptable coefficient alphas (.85 for experimental learning; .84 for adaptive learning).

Measurement model

The constructs measured via the survey (experimental learning, adaptive learning, and environmental dynamism) were examined for unidimensionality and convergent validity with confirmatory factor analysis (CFA). As shown in the Appendix, the CFA model suggests acceptable fit indices. All items load on their respective constructs with each loading significant at the .01 level, in support of convergent validity (Anderson and Gerbing 1988). To assess the constructs' discriminant validity, we compared an unconstrained CFA model with a CFA model in which the correlation between a pair of constructs is constrained to 1. The unconstrained model fits significantly better than the constrained model (Bagozzi et al. 1991). The pairwise chi-square difference tests indicate that in each case, the chi-square difference statistic is significant at the .01 level, in support of discriminant validity. Also, all pairs of constructs pass Fornell and Larcker's (1981) more stringent test of discriminant validity as the average variance extracted by each construct is greater than the squared correlation between any two constructs.

At the industry level, the analysis controls for environmental dynamism since prior research in this area often notes the potential effect of turbulent environments on innovation (Im and Workman 2004; Singh 1986). Specifically, five 7-point Likert scale items were adapted from Jaworski and Kohli (1993) to evaluate the extent to which customer preferences, technology, and competitors' actions change rapidly and unpredictably. The coefficient alpha for this measure is .81. At the firm level, control variables were utilized for innovation stock, R&D intensity, and firm size, using data from COMPUSTAT. Innovation stock is measured as the number of patents granted and normalized via a natural log-transformation. R&D intensity is measured as the average ratio of R&D expenditures divided by sales (Prabhu et al. 2005). Firm size is measured as the log-transformation of the average number of employees. Finally, to avoid common method bias, this research follows prior recommendations of Podsakoff et al. (2003) to use multiple data sources; the primary survey is used for independent variables while archival data are used for dependent variables (Rindfleisch et al. 2008). This multi-method approach prevents concerns over common method bias. Table 2 displays the descriptive statistics and correlation matrix.

Analysis and results

The model is summarized in the following three equations.

$$\text{Tobin's q} = \alpha_{10} + \alpha_{11} IM + \alpha_{12} IN + \alpha_{13} IM^{*} IN + \alpha_{14} firmsize + \alpha_{15} R\&D + \alpha_{16} IS + \alpha_{17} ED + e_1 \quad (1)$$

Table 2 Descriptive statistics and correlation matrix

Constructs	Means	Standard deviations	Correlations									
			1	2	3	4	5	6	7	8	9	10
1 Tobin's q	1.13	1.28	1.00									
2 Experimental learning	3.95	1.19	- .05	1.00								
3 Adaptive learning	4.32	1.32	.07	- .13	1.00							
4 Innovation meaningfulness	0.65	0.69	.18*	- .16*	.15*	1.00						
5 Innovation novelty (reverse coded)	58.35	34.04	.04	- .11	.15*	.28*	1.00					
6 Unabsorbed slack resources	0.05	0.47	.02	.07	.03	- .16*	.10	1.00				
7 Innovation stock	2.45	0.72	.12	- .22*	.12	.09	- .02	- .03	1.00			
8 R&D intensity	0.25	0.89	.09	.02	- .09	.20*	-.01	.02	.11	1.00		
9 Firm size	5.34	2.86	- .07	- .04	- .07	.05	- .08	- .02	.26**	- .12	1.00	
10 Environmental dynamism	4.00	1.34	- .04	- .09	- .12	- .06	.07	.07	.03	.11	.06	1.00

** $p < .01$; * $p < .05$

$$IM = \alpha_{20} + \alpha_{21}AL + \alpha_{22}EL + \alpha_{23}SR + \alpha_{24}AL^{*}SR + \alpha_{25}EL^{*}SR + \alpha_{26}firmsize + \alpha_{27}R\&D + \alpha_{28}IS + \alpha_{29}ED + e_2 \quad (2)$$

$$IN = \alpha_{30} + \alpha_{31}AL + \alpha_{32}EL + \alpha_{33}SR + \alpha_{34}AL^{*}SR + \alpha_{35}EL^{*}SR + \alpha_{36}firmsize + \alpha_{37}R\&D + \alpha_{38}IS + \alpha_{39}ED + e_3 \quad (3)$$

Where IM = innovation meaningfulness, IN = innovation novelty, IS = innovation stock, AL = adaptive learning, EL = experimental learning, SR = unabsorbed slack resources, and ED = environmental dynamism.

We employ path analysis because structural equation modeling allows the equations to be tested simultaneously. Both independent and moderating variables are mean-centered to reduce potential multicollinearity issues (Aiken and West 1991). Results appear in Table 3.

H1a, which hypothesizes a positive effect for experimental learning on novelty, is in the hypothesized direction but is not statistically significant and is thus not supported (β = .09, n.s.). However, H1b, which argues a negative effect for experimental learning on meaningfulness, is supported (β = −.14 $p < .05$). Both H2a and H2b are supported, as adaptive learning negatively affects novelty (β = −.13, $p < .05$) and positively affects meaningfulness (β = .15, $p < .05$). With regard to the moderating effects of unabsorbed slack resources, H3a is supported because unabsorbed slack positively moderates the relationship between experimental learning and novelty (β = .21, $p < .05$). However, H3b is not supported because the moderating effect of unabsorbed slack on the experimental learning–innovation meaningfulness relationship is not significant (β = −.04, n.s.). H3c is supported in that a firm's unabsorbed slack negatively moderates the relationship between adaptive learning and novelty (β = −.18, $p < .05$), while H3d is not supported because the moderating effect on the adaptive learning–innovation meaningfulness relationship is not significant (β = .05, n.s.).

The final hypotheses test the relationship among novelty, meaningfulness, and shareholder value. H4a, which predicts that novelty positively impacts shareholder value, is not supported (β = −0.09, n.s.). However, H4b is supported because meaningfulness positively affects shareholder value (β = .16, $p < .05$). Finally, the interaction between novelty and meaningfulness has a positive effect on shareholder value, in support of H4c (β = .13, $p < .05$).

Discussion and implications

This research delineates the organizational learning modes of experimental and adaptive learning, and distinguishes technological innovation into the separate dimensions of novelty and meaningfulness, to examine the effects of learning on novelty and meaningfulness, together with unabsorbed slack resources, and their impact on shareholder value. Overall, the analysis indicates that experimental learning and adaptive learning have opposite effects on novelty and meaningfulness. The external focus of adaptive learning heightens the firm's sensitivity to environmental conditions that are more closely linked with meaningfulness. This sequential learning mode guides the firm to adapt its learning to extend the firm's knowledge in response to emergent market opportunities. By pursuing areas that are valued by the environment, the

Table 3 Results of path analysis

Variables	Dependent variables (Standardized coefficients)		
	Innovation meaningfulness	Innovation novelty	Tobin's q
Control variables			
Innovation stock	.04	.07	.04
R&D investment	.22*	−.03	.07
Firm size	.06	−.07	−.08†
Environmental dynamism	−.09†	.07	−.04
Independent variables			
Experimental learning	−.14*	.09	–
Adaptive learning	.15*	−.13*	–
Unabsorbed slack resources	−.15*	−.08	–
Innovation novelty	–	–	−.09
Innovation meaningfulness	–	–	.16*
Moderating effects			
Experimental learning * Unabsorbed	−.04	.21*	–
Adaptive learning * Unabsorbed slack resources	.05	−.18*	–
Innovation novelty * Innovation meaningfulness	–	–	.13*
R^2	.13	.07	.06

Fit Indices: Chi-square (d.f. = 15): 79.78; GFI: .93; CFI: .93; NFI: 0.89; RMSEA: .07

** $p < .01$; * $p < .05$; † $p < .10$

firm's technological innovation exhibits higher meaningfulness. Yet by reacting to external conditions, adaptive learning encumbers novelty. Firms that emphasize adaptive learning tend to work more narrowly on solutions for specifically identified domains. Such firms may myopically focus on known external opportunities that fall within a more limited scope of knowledge. This focus biases firms against unfamiliar knowledge areas and constrains organizations from pursuing distant domains that may hold the potential for greater innovation novelty.

In contrast, the results find a negative effect for experimental learning on meaningfulness. This could be due to an over-emphasis on trial-and-error experimentation, which may discourage the firm from accumulating domain-specific expertise to cultivate meaningful technologies that have a high impact on future innovation. Experimentation sometimes leads to unexpected benefits, but these discoveries are not always codified by the firm to become part of the organization's knowledge that guides future innovation activities (Moorman and Miner 1998b). Additionally, our moderated results suggest that experimental learning enhances novelty only when a firm has sufficient unabsorbed slack resources to adjust its resource allocation in concert with experimentation. The excess, uncommitted slack permits developers to avoid competing with internal groups over limited resources. This flexibility facilitates the pursuit of risky technologies without having to give preference to ideas that are less risky but have a lower probability of failure. Taken together, these findings suggest that when novelty is a desired attribute of technological innovation, unabsorbed slack resources should be deployed in conjunction with the strategic use of experimental learning.

To demonstrate the interaction of experimental learning with unabsorbed slack resources, a simple slope analysis considers conditions of high unabsorbed slack (one standard deviation above the mean) and low unabsorbed slack (one standard deviation below the mean). As Fig. 2, Panel A, reveals, experimental learning has a positive effect on novelty when unabsorbed slack is high, but a negative effect on novelty when unabsorbed slack is low. Thus, a lack of unabsorbed slack encumbers experimental learning's benefits for novelty. This negative scenario may occur if the firm has insufficient latitude to pursue long-term projects with uncertain outcomes. Combining these results with the insignificant relationship between experimental learning and novelty suggests that experimental learning spurs novelty only when a firm has sufficient unabsorbed slack resources and, thus, the necessary flexibility to allocate resources to accommodate experimentation. In contrast, Fig. 2, Panel B, indicates that a high level of unabsorbed slack appears to amplify the negative effect of adaptive learning on novelty.

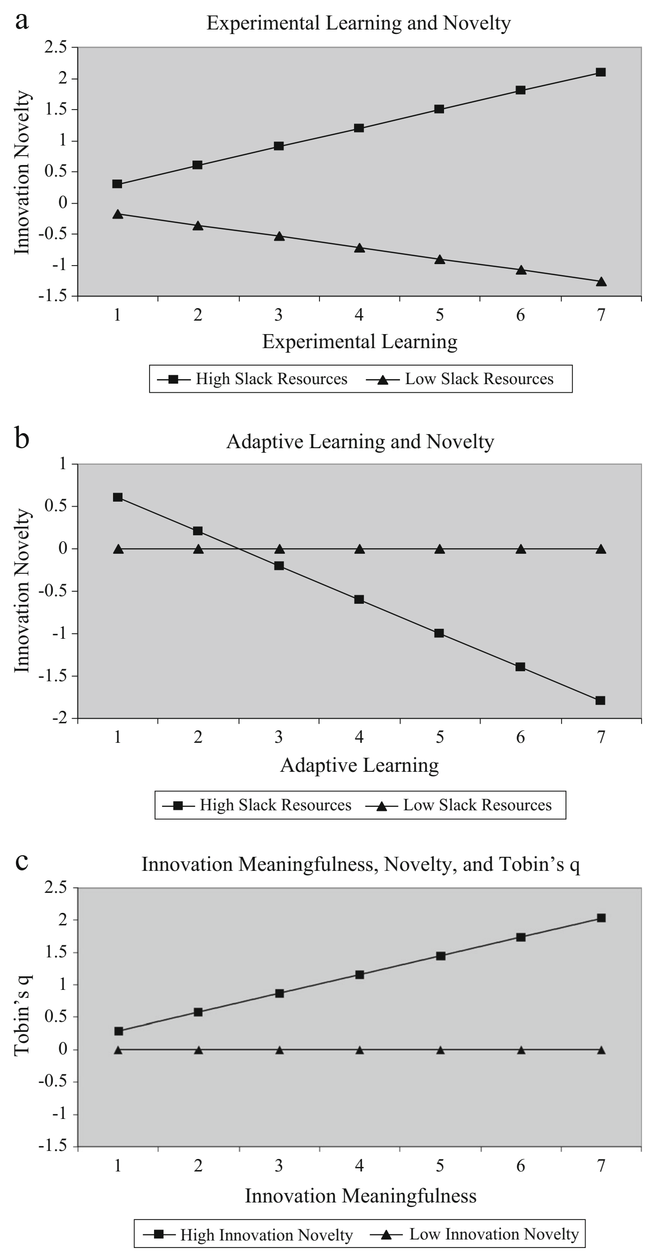

Fig. 2 **a** Experimental learning and novelty. **b** Adaptive learning and novelty. **c** Innovation meaningfulness, novelty, and Tobin's q

Additionally, we note that neither of the interactions of unabsorbed slack with experimental and adaptive learning are statistically significant in their effects on meaningfulness. Prior scholars suggest that slack is associated with managerial changes in routines to pursue development of varied product ideas (Katsikeas et al. 2016) and that slack may diminish discipline in innovation projects (Stock et al. 2013). Accordingly, slack may not offer the appropriate resources to focus firms' learning efforts on technological opportunities that are defined as valuable by the external environment. Thus, our findings suggest that it is not necessary for firms to provide unabsorbed slack resources when they engage in learning activities to pursue innovation meaningfulness.

Ultimately, the results empirically establish the effects of technological innovation on firm shareholder value. In particular, meaningfulness has a positive, direct impact on shareholder value. Additionally, the findings reveal how firms may combine the two dimensions of technological innovation to achieve higher firm performance. To demonstrate the interaction of novelty and meaningfulness, a simple slope analysis considers the effects under conditions of high novelty and low novelty. Figure 2, Panel C, shows that meaningfulness has a more pronounced positive effect on firm performance when novelty is high. In other words, novelty and meaningfulness contribute to a firm's financial value through different, yet complementary, mechanisms. This insight underscores the necessity of treating novelty and meaningfulness as separate dimensions that can independently, and jointly, drive shareholder value.

Theoretical implications

These results have several theoretical implications. First, novelty and meaningfulness are often treated as congruent aspects of technological innovation, which creates a biased picture of the connection of organizational learning mechanisms to innovation in different strategic contexts. A meta-analysis by Szymanski et al. (2007) shows that there is great variance in the measures used to study innovation. Their review suggests consensus among researchers that novelty is a core dimension of innovation. However, they also reveal that innovation measures should include a dimension of meaningfulness, which exhibits a much stronger relationship with performance outcomes than studies that only use the novelty dimension (Szymanski et al. 2007). Our manuscript seeks to build upon this innovation literature, as well as more recent studies that now recognize the importance of this distinction (e.g., Stock and Reiferscheid 2014), by theoretically distinguishing novelty and meaningfulness to deepen marketing researchers' understanding of the differences between, and performance outcomes of technological innovation.

Second, by considering the separate dimensions of novelty and meaningfulness, theory is more likely to unearth new insights into the foundations and roles of technological innovation. This perspective is especially important to cultivate further research on technological innovation in the marketing literature, which has tended to give greater focus to the study of product innovation. To that end, we incorporate the organizational learning literature by defining and measuring two distinct organizational learning approaches that influence novelty and meaningfulness. In doing so, the results provide explanations for the conflicting findings regarding organizational learning and innovation that have been encountered in prior research. For example, Moorman and Miner (1997) find that the level of organizational memory that results from organizational learning activities may have a negative connection to innovation, whereas others scholars suggest a positive relationship between learning and innovation (e.g., Zhou et al. 2005). Our research suggests that these discrepancies may be explained by differences in the mode of organizational learning (i.e. experimental and adaptive). The opposite effects of experimental and adaptive learning on novelty and meaningfulness imply that the learning–innovation relationship must be understood according to different learning styles and separate considerations of novelty and meaningfulness. The contrasting findings of adaptive and experimental learning with novelty and meaningfulness underscore the need for marketing scholarship to embrace a more fine-grained conceptualization of technological innovation to facilitate further research in this domain.

Third, this manuscript's results offer a nuanced explanation for the inconsistencies that prior studies have encountered in the relationship between organizational slack resources and innovation (Nohria and Gulati 1996). The effects of slack resources conflict because unabsorbed slack provides more flexibility and eases internal tensions for the benefit of some aspects of learning's relationship with technological innovation, but also breeds inertia and complacencies that harm other areas of learning's relationship with technological innovation. Our research shows that the effects of a firm's unabsorbed slack may depend on the context of the firm's learning mode, because unabsorbed slack has opposite moderating effects for influencing adaptive and experimental learning's relationships with novelty. To garner novelty, the moderating effects suggest that unabsorbed slack should be coupled with experimental learning.

Managerial implications

The findings of this research offer substantive implications for marketers seeking to develop a successful technological innovation strategy. The achievement of technological innovation meaningfulness and novelty is challenging for managers and requires the strategic alignment of innovation goals and organizational learning activities with the effective allocation of unabsorbed slack resources. We decompose the challenges of technological innovation into three key relationships: (1) the impact of organizational learning modes on novelty and meaningfulness, (2) the moderating influence of unabsorbed slack resources on the effects of organizational learning on novelty and meaningfulness, and (3) the impact of novelty and meaningfulness on shareholder value. The results provide guidance for firms to strategically leverage different organizational learning approaches to effectively pursue the appropriately aligned goals. Further, we document the effects of these relationships, which may help practitioners to effectively manage their interdependencies.

To create an appropriate strategy, managers should first determine which type of technological innovation they seek to achieve. Technological innovation meaningfulness offers value that the market recognizes both immediately and in the future, whereas novelty offers value by increasing the difficulty of imitation and substitutability by competitors. Our results advise firms seeking technological innovation meaningfulness to use adaptive learning, with its focus on aligning the organization's knowledge activities with external conditions, while restricting the availability of unabsorbed slack resources. Similarly, managers faced with a lack of unabsorbed slack resources should encourage adaptive learning as a viable path to achieving technological innovation meaningfulness. In contrast, managers seeking technological innovation meaningfulness are cautioned to avoid experimental learning due to its negative influence.

If a firm seeks technological innovation novelty, our research advises managers to utilize experimental learning in conjunction with the deployment of unabsorbed slack resources. Although we find that experimental learning alone is insufficient to garner novelty, managers should provide unabsorbed slack resources in concert with the use of experimental learning to facilitate the pursuit of riskier ideas that may seem uncertain, yet are connected with greater novelty. In contrast, our research advises managers that a focus on adaptive learning harms novelty. The reactive approach of adaptive learning may cause firms to be reluctant to consider unfamiliar knowledge areas that could provide opportunities for greater novelty. Moreover, a high level of unabsorbed slack resources combined with adaptive learning produces an unfavorable interaction effect to the further detriment of novelty. Instead, managers should avoid reliance upon adaptive learning, and especially the combination of adaptive learning with a misallocation of unabsorbed slack resources, if they seek novelty as a goal. Consequently, our research recommends that a mere focus on organizational learning activities is inadequate to yield technological innovation novelty, since the type of learning mechanism must be considered concurrently with unabsorbed slack resources to understand their interaction effects. Thus, organizational learning modes and unabsorbed slack resources should be implemented purposefully to foster the desired characteristics of the firm's technological innovation strategy.

Finally, we advise managers of the potential payoff to shareholder value that firms may expect to achieve from their technological innovation strategy. In particular, for firms in which increasing shareholder value is a primary goal, we propose that the meaningfulness aspect of technological innovation should not be overlooked by managers since it has a direct impact on firm financial performance. Although managers often emphasize the novelty aspect of innovation, our empirical results indicate that technological innovation meaningfulness drives shareholder value. Moreover, while meaningfulness provides direct value, novelty amplifies this effect to provide joint financial returns. By helping the firm protect its competitive position through differentiation from existing knowledge bases, novelty works in conjunction with meaningfulness to produce synergistic value that is of interest to firms and their shareholders. This finding is crucial for firms managing their technological innovation portfolios since not including meaningfulness results in incorrect conclusions about the impact of novelty on shareholder value. These implications are especially relevant for firms competing in high-tech industries, where technological innovation is critical for firm success.

Limitations and future research

This research contains several limitations that offer potential opportunities for future studies. With regard to patent data, our operationalization of novelty is supported by prior literature (Ahuja and Lampert 2001; Chandy et al. 2006), yet it is not the only means to measure novelty. For example, some researchers have suggested novelty is sometimes achieved through a unique recombination of existing knowledge (Yang et al. 2010). Moreover, although previous studies have adopted patent citation information as a measure of novelty and meaningfulness, patents do not capture all aspects of technological innovation. Future studies could adopt measures based on other important factors, such as market entry timing, development costs, product sales, and customer satisfaction (Cankurtaran et al. 2013). A broader collection of innovation input and output measures would offer supplemental managerial implications for firms that do not emphasize patents as a core part of their technological innovation strategy.

Another potential area for future research would be to collect data in different contexts related to organizational learning. This manuscript relies on key informants to report firms' level of experimental learning and adaptive learning. While the respondents indicate a sufficient level of knowledge about the survey items, additional studies may benefit from the use of multiple respondents. In particular, it may be insightful for future research to collect panel data from multiple informants to study how organizational learning strategies change over time. Some firms may initially take an experimental learning approach to understand an unfamiliar knowledge domain. As a market develops and becomes ready to adopt an emerging technology, the firm may switch to an adaptive learning approach to create impactful innovation that can be calibrated to meet changing customer preferences. Panel data would enable an investigation of how firms adjust their organizational learning strategies over time, and how these adjustments affect novelty, meaningfulness, and performance.

Future studies might also pursue complementary research areas. Our research examines only one strategic context, unabsorbed slack resources. Further research could consider absorbed slack resources, such as recoverable slack and potential slack (Daniel et al. 2004), as possible factors that moderate experimental and adaptive learning's effects on technological innovation. Recoverable slack includes resources that are already absorbed into the firm's operations as costs but can be recovered through internal changes to the organization (Cheng and Kesner 1997). Firms that operate in extremely lean environments may not have the ability to readily offer unabsorbed slack resources to support experimental learning activities. Rather, such firms may have to access recoverable slack as a means to aid their goals that pertain to technological innovation novelty. A related opportunity is to investigate the non-significant effects of unabsorbed slack in moderating experimental and adaptive learning's impact on meaningfulness. While our models found strong moderating effects for novelty, future researchers could examine potential conditions where unabsorbed slack may significantly impact meaningfulness.

Other strategic context factors, such as a firm's competitive position in an industry, may extend this manuscript's findings. For example, first movers in an industry might rely more on experimental learning. It would be interesting to examine how pioneers use different modes of organizational learning to create and maintain their position over time. Further, certain industries may exhibit greater levels of experimental learning activities while others may be dominated by firms that focus on adaptive learning. Future research could incorporate industry characteristics that influence the organizational learning mode that firms choose to undertake.

Finally, firm financial value represents only one financial metric that is important to managers. Additional studies could examine how organizational learning and technological innovation novelty and meaningfulness might reduce firm risk while simultaneously enhancing sales and other measures of shareholder value.

Appendix

Items and constructs	Factor loading
Experimental Learning (coefficient alpha: 0.85, average variance extracted: 0.63)	
1. Our firm stresses the importance of learning from R&D experimentation.	0.85
2. Our firm often experiments with different development approaches and methods to enhance our R&D knowledge.	0.75
3. Our firm encourages employees to try different development methods to enhance our R&D knowledge, even though the outcomes of these methods are uncertain.	0.81
4. Our firm regards failures of R&D experimentation activities as learning experiences, rather than development costs.	0.76
5. We gain a great deal of knowledge through our repeated trial-and-error R&D processes.	0.78
Adaptive Learning (coefficient alpha: 0.84, average variance extracted: 0.62)	
1. Our firm emphasizes the importance of tracking the R&D activities by industry leaders.	0.82
2. Our firm encourages researchers and developers to adjust their skills and knowledge to catch up with industry leaders.	0.87
3. We adapt our R&D approaches to follow technological opportunities pursued by industry leaders.	0.72
4. Our firm continuously improves our innovation knowledge to face industry leaders.	0.79
5. We consistently keep track of the differences we have with industry leaders.	0.73
Environmental Dynamism (coefficient alpha: 0.81, average variance extracted: 0.60)	
1. In the market, customers' preferences change quickly over time.	0.88
2. Market demand and consumer tastes have been unpredictable.	0.69
3. Actions of competitors have been highly unpredictable.	0.74
4. The competition of our firm is changing very rapidly.	0.77
5. It is very difficult to forecast where technology will be in the next five years.	0.82
Model Fit Indices: chi-square (d.f. = 87): 134.87; GFI: .92; CFI: .97; NFI: 0.90; RMSEA: .05	

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