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Connecting the unconnected: Analogies and the development of insight in the absorptive capacity process

Desmond Ng | **Leonardo Sánchez-Aragón**

Texas A&M University, College Station, Texas, USA

Correspondence
Desmond Ng, Texas A&M University, College Station, TX 77843, USA.
Email: dng@tamu.edu

While innovation has been widely attributed to a firm's absorptive capacity (AC), product and marketing studies have found that insight is central to a firm's creativity and innovation. Creativity and innovation studies have found that individuals often relate to external information through an analogical reasoning process and that this process develops insight into a firm's innovation. Although the AC concept has been associated with this insight, it however faces significant difficulties explaining its development. This is because AC has been defined by a social structure where myopic tendencies can preclude its individual members from assimilating new external experiences. As insight often requires an exposure to previously unconnected or unrelated experiences, this myopia can reduce a firm's ability to produce insight in its AC process. By drawing on an individual level analogical reasoning process, this study argues that a firm's coherence and uniqueness offer a social structure that not only leverages this individual level analogical reasoning process but also produces an assimilation that develops insight in the firm's AC process. In using a sample of US biotechnology firms, this study finds empirical support for these arguments to explain the development of insight in ways not possible with AC explanations.

KEYWORDS
absorptive capacity, analogical reasoning, coherence, uniqueness

1 | INTRODUCTION

> *Creativity is the power to connect the seemingly unconnected.*
>
> William Plomer

Various product and marketing studies have shown that the development of insight is central to a firm's creativity and innovation (Dahl & Moreau, 2002; Gassmann & Zeschky, 2008; Jeong & Kim, 2014). This is because insight offers a deep understanding of the information environment in ways that overcome impasses from previously established views. For instance, in Hargadon and Sutton's (1997) study of the product design firm IDEO, design engineers developed insights by drawing on connections to technologies that were not previously related to their current design problems. These insights offered novel solutions to overcoming problems that could not have been solved by the firm's established engineering designs. As such insight requires a deep understanding of a firm's information environment, absorptive capacity (AC) research offers a means to develop this understanding (e.g., Božič & Dimovski, 2019; Müller et al., 2021). AC refers to a firm's ability to recognize, assimilate and exploit external information (Cohen & Levinthal, 1990) where studies find this ability has been associated with a firm's insight (Božič & Dimovski, 2019; Cohen & Levinthal, 1990; Müller et al., 2021; Zahra & George, 2002). This is because a firm's assimilation of external experiences creates new external associations that offer new perspectives to impacting a firm's innovative performance. For instance, in Muller et al.'s (2021) AC study of German Small Medium Enterprises (SMEs), they found a SME's ability to assimilate information about their customer needs offered insights in developing new business models that better served their needs.

While the concept of AC offers an attractive approach to explaining a firm's insights, there are challenges in explaining its development. These challenges are rooted in structural explanations of the AC concept (Cohen & Levinthal, 1990; Enkel et al., 2018; Jansen et al., 2005; Todorova & Durisin, 2007; Zahra & George, 2002). According to Cohen and Levinthal (1990), AC is a 'distinctly organizational' (p. 131) level concept where a firm's AC extends beyond the AC of its members. This AC includes a social structure involving a set of 'overlapping experiences' (Cohen & Levinthal, 1990; p. 133) that increase efficiencies in a firm's ability to assimilate external information (Jo et al., 2016; Lane & Lubatkin, 1998). This structure also consists of a diversity of connected experiences that enable the firm to create novel associations with its external environment (e.g., Enkel & Heil, 2014; Lin et al., 2012). Furthermore, since this social structure is comprised of the experiences of its members (Cohen & Levinthal, 1990), AC researchers have argued that individual members can engage in an assimilation and transformation that can affirm the assimilative and creative benefits of this social structure (e.g., Todorova & Durisin, 2007). Yet the challenge with these social structural explanations is that Cohen and Levinthal (1990) and others (Kauppila, 2015; Kim et al., 2016) have argued that the assimilative benefits of a social structure can drive out the knowledge creation benefits of its diversity.

This is because since an individual's assimilation and transformation operate with a greater social structure of shared experiences, AC studies have found that members of this social structure will assimilate external information in ways that reinforce their shared understandings (Kim et al., 2016; Lin et al., 2012; Schildt et al., 2012). AC studies have argued that this exchange of similar information can create myopic behaviours that reduce an individual member's ability to associate with new or previously unconnected ideas (Kauppila, 2015; Kim et al., 2016; Saiz et al., 2018). This myopia can reduce an individual member's ability to transform their past experiences and reduce their ability to produce novel insight. Hence, the challenge facing AC research is that the firm's social structure prevents the transformation of experiences (Todorova & Durisin, 2007) that are needed to develop the firm's insight. The following research questions are posed: Since a firm's AC has been widely associated with its innovative performance, how can a firm develop social structures that produce insight in its AC process and how does this AC process influence its innovative performance?

The objective of this study is to develop and empirically examine a social structural concept of AC that addresses these research questions. In developing this study's AC concept, innovation studies have argued that individuals appeal to analogies as a powerful source of insight (Dahl & Moreau, 2002; Gavetti et al., 2005; Kalogerakis et al., 2010). These analogies involve a reason by analogy process (RAP) in which individuals gain insight by relating the solutions of one knowledge domain to solving the problems of another. For instance, Thomas Edison and his colleagues drew on their insights of electromagnetic power from the telegraph industry to solving the technical problems in the lightning, telephone, phonograph, railway and mining industries (Hargadon & Sutton, 1997). Yet, as the development of such insight is a highly individualized learning process, analogical (Dahl & Moreau, 2002; Gavetti et al., 2005; Kalogerakis et al., 2010)—as well as AC (Enkel & Heil, 2014)—research do not explain the social structures that connect to this individual level learning process (see, e.g., Song et al., 2018; Todorova & Durisin, 2007; Zahra & George, 2002). This study argues that an organizational concept of coherence (Foss & Christensen, 2001; Leten et al., 2007; Lien & Klein, 2013; Nesta & Saviotti, 2005; Teece et al., 1994) offers such a social structure. Studies have shown that coherent firms exhibit a relatedness in their combined business activities and that a shared or common understanding of these related activities influences a firm's AC (Leten et al., 2007; Lien & Klein, 2013; Teece et al., 1994). This study argues that coherence offers a social structure that relates the knowledge domains of an individual's RAP process and that a shared understanding of these related domains influences the development of insight in the firm's AC. In addition, this study argues that a unique social structure—consisting of a diverse set of network connections—integrates distant knowledge domains into an individual's RAP process. This structure also promotes the development of insights in a firm's AC process. In using patent data from the US biotechnology industry, hypotheses were developed to empirically examine the innovative performance of a firm's coherent and unique social structures.

This study offers two contributions to AC research. First, as AC involves the assimilation and transformation of new knowledge experiences (Kim et al., 2016; Todorova & Durisin, 2007; Yao & Chang, 2017; Zahra & George, 2002), a firm's coherence and uniqueness offer an exploitation where the assimilation of external solutions transforms its members' ability to develop new insights. These concepts can overcome the myopic problems found in structural explanations of AC research. Second, the exploitation of a firm's coherence and uniqueness introduces a higher order learning to the AC process. This higher order learning suggests that, unlike the individual level processes described in AC research, the separation of an individual's assimilation and transformation process (Todorova & Durisin, 2007) would reduce this higher order learning and thus reduce the innovative potential of the AC concept.

2 | CONCEPTUAL DEVELOPMENTS

2.1 | Concept of AC

AC is commonly defined by 'the ability of a firm to recognize the value of new, external information, assimilate it, and apply it to commercial ends' (Cohen & Levinthal, 1990, p. 128). A basic premise underlying this concept is that 'prior knowledge' is essential to the assimilation of new and external knowledge (Cohen & Levinthal, 1990; Volberda et al., 2010). This observation is rooted in cognitive-memory research where Cohen and Levinthal (1990) argued ‘that the concept of absorptive capacity can best be developed through an examination of the cognitive structures that underlie learning’ (p. 129). These cognitive structures involve an individual level ‘associative learning’ process where individuals store information events into memory ‘by establishing linkages amongst pre-existing concepts’ (p. 129). These associations increase a member's ability to recall patterns from their experiences and to apply these patterns into assimilating novel associations with a firm's external environment (Cohen & Levinthal, 1990).

Given the importance of these learning associations, Todorova and Durisin (2007) extends Cohen and Levinthal's (1990) cognitive explanations by offering two distinct associative learning processes involving assimilation and transformation. Assimilation involves associating new ideas that fit well into the individual's existing cognitive schema (i.e., assumptions, models and experiences), where the idea is modified to fit the individual's cognitive schema. While this assimilation is consistent with Cohen and Levinthal's (1990) associative learning process, Todorova and Durisin (2007) argue that the assimilation of novel experiences requires an alternative associational process. They argue that, when external ideas cannot be modified, novel ideas are assimilated through a transformation where the individual's cognitive structure is modified to fit these external ideas. This transformation introduces new patterns of associations or experiences that enable individuals to associate with new ideas not possible with assimilation. This suggests that assimilation and transformation reflect distinct associational processes where individuals can engage in either the assimilation or transformation of external experiences but not both (Todorova & Durisin, 2007).

While these (Todorova & Durisin, 2007) and other related associational processes (Kim et al., 2016; Lane & Lubatkin, 1998; Yáñez-Araque et al., 2017) have enriched the cognitive underpinnings of the AC concept, Cohen and Levinthal (1990) have argued that AC is a ‘distinctly organizational’ level phenomenon that extends well beyond the cognition/experiences of its individual members. This organizational level phenomena refers to a social structure that connects the knowledge and experiences of specialized members (Cohen & Levinthal, 1990; Yao & Chang, 2017). Specifically, this social structure consists of an ‘overlapping’ set of connected experiences where a shared understanding of language, codes and symbols increases efficiencies in transferring external information to (1) a firm's connected members and (2) to those who are in the best position to exploit this assimilated information (Cohen & Levinthal, 1990; Jo et al., 2016; Schildt et al., 2012). For instance, AC studies find that these shared understandings increase the transfer, codification and assimilation of external experiences (Jo et al., 2016; Lane & Lubatkin, 1998; Yáñez-Araque et al., 2017; Yao & Chang, 2017) and that these shared understandings increase efficiencies in a firm's ability to assimilate external information. Cohen and Levinthal (1990) further argued that a firm's social structure requires a ‘sufficient’ degree of diversity. This is because a diverse background increases the firm's ability to assimilate information from a broader range of information environments (see also Enkel et al., 2018; Enkel & Heil, 2014; Santoro et al., 2020).

In recognizing these structural benefits, dynamic capability (DC) explanations (Song et al., 2018; Todorova & Durisin, 2007; Zahra & George, 2002) have extended Cohen and Levinthal's (1990) social structural explanations. According to this DC view, a firm's social structure is explained by its social integrating mechanisms (Enkel et al., 2018; Jansen et al., 2005; Todorova & Durisin, 2007; Zahra & George, 2002). Social integration mechanisms ‘refer to the shared values, norms, and other mechanisms that build connectedness and socialization among members of an organization but also among collaborating partners that are not part of the same organization’ (Enkel et al., 2018, p. 1262).

Jansen et al. (2005) argued that these social integration mechanisms offer a means to manage the potential (PACAP) and realized (RACAP) aspects of a firm's AC (Zahra & George, 2002). A firm's potential absorptive capacity (PACAP)—consisting of acquisition and assimilation—promotes an exploration of external information, while a firm's realized absorptive capacity (RACAP)—involving transformation and exploitation—seeks to recombine this external information in ways that leverage a firm's internal competencies (Ahmed et al., 2019; Engelman et al., 2017; Kostopoulos et al., 2011; Todorova & Durisin, 2007; Zahra & George, 2002; Zobel, 2017). Jansen et al. (2005) and others (Enkel et al., 2018; Yang & Tsai, 2019) show that a firm's social integration mechanisms—involving the use of cross-functional teams—integrate diverse member experiences and that they increase a firm's PACAP to adapt to changing external conditions. These cross-functional teams also promote an integration and recombination of external/internal experiences and thus influence a firm's RACAP (Jansen et al., 2005). These and other related social integration mechanisms have been argued and or found to have a positive influence on the firm's innovative performance (Jansen et al., 2005; Kang & Lee, 2017; Zhao et al., 2020). For instance, Kang and Lee's (2017) study found that social integration mechanisms offer a shared knowledge that increases a firm's PACAP and RACAP and that this shared understanding increased an employee's innovative performance.

While social structural explanations have played an important role to the AC concept, these social structural explanations are vulnerable to myopic or competency trap-like behaviours. This is because a basic tenet of the AC concept is that individuals assimilate information in ways that affirm their past experiences (Cohen & Levinthal, 1990, p. 131; Kauppila, 2015; Kim et al., 2016; Saiz et al., 2018; Volberda et al., 2010). This assimilation can create a social structure in which members are connected to increasingly similar or redundant experiences. Such redundancy produces myopic and competency trap-like behaviours that impede members' ability to discover novel associations with their external environment (Jo et al., 2016; Schildt et al., 2012). Authors like Todorova and Durisin (2007) would argue that an individual's transformation can develop new associations that mitigate such myopic tendencies. The challenge with this explanation is that since an individual's transformation operates within a greater social structure, the overlapping or redundant connections of this social structure would prevent these individuals from associating with new experiences and thus reduce an individual's transformation.

For instance, Cohen and Levinthal (1990) and others (Jo et al., 2016; Kauppila, 2015; Kim et al., 2016; Saiz et al., 2018; Schildt et al., 2012) argued that an overlapping social structure can produce an 'inward looking absorptive capacity' (Cohen & Levinthal, 1990) that insulates individuals from new external experiences. Such myopic behaviours have also been recognized in DC explanations, where Jansen et al. (2005) argued that redundant social structures and socialization tactics can negatively influence a firm's PACAP and RACAP. This is also consistent with network and AC studies that have argued highly embedded or redundant social structures reduce the assimilation of new external experiences (Kauppila, 2015; Kim et al., 2016; Lin et al., 2012; Schildt et al., 2012). As a result, these studies suggest social structures can insulate the firm from new experiences to which prevent its members from transforming their cognitive schemas into discovering new ways to relate to their information environment.

2.2 | Reason by analogy process

In departing from the cognitive and associative learning processes of AC research (Cohen & Levinthal, 1990; Kim et al., 2016; Todorova & Durisin, 2007; Yao & Chang, 2017), innovation studies find individuals relate to their external environment through a RAP (Enkel & Heil, 2014; Gassmann & Zeschky, 2008; Gavetti et al., 2005; Kalogerakis et al., 2010). A RAP involves a structural mapping process in which an individual applies the solutions of a base knowledge domain to solving the problems of a target domain (Gavetti et al., 2005; Gentner & Colhoun, 2010; Gentner & Markman, 1997). A target domain can be a design problem or concept that an individual seeks to explain or solve (Christensen & Schunn, 2007; Dunbar, 1997; Kalogerakis et al., 2010). The base domain consists of a set of external solutions in which the individual draws on to understand the target (Dunbar, 1997; Kalogerakis et al., 2010). An analogy is formed when the external solutions of the base domain are structurally mapped to solving the problems of the target domain (Christensen & Schunn, 2007; Dunbar, 1997; Gavetti et al., 2005). The implication to AC research (Cohen & Levinthal, 1990; Todorova & Durisin, 2007) is that because RAP is a problem driven process, an individual's assimilation or transmission is not based on the fitness of the external information to their cognitive schemes. Rather, RAP involves an associative learning process where this fitness is based on the extent to which the external solution solves the individual's problems. This suggests that unlike Todorova and Durisin (2007), an individual's assimilation and transformation are related learning processes, because RAP introduces a relatedness where the assimilation of external solutions from a base domain transforms an individual's understanding of their targeted problem. Analogical research argues that this relatedness offers a source of insight because it enables the individual to relate to external information in ways not previously considered (Dahl & Moreau, 2002; Gavetti et al., 2005; Hargadon & Sutton, 1997). As the RAP is an important source of insight, this insight is defined by a structural mapping process in which an individual draws on the external solutions of a base domain to developing solutions to a targeted problem.

To illustrate this insight, the development of CRISPR (Clustered Regularly Interspaced Short Palindromic Repeats) has been one of the most significant technological breakthroughs in genetic engineering. CRISPR offers an unprecedented tool to target, delete and replace specific genes in any organism and has the potential to offer revolutionary advances in cancer therapies, develop resistances in animal and plant products and eliminate various genetic disorders. Yet, despite these modern genomic advances, micro-biologists have long recognized and understood that bacteria for millions of years have been using the CRISPR system as a natural defense against viruses. It was not until 2012–2013 that molecular biologists, Drs. Jennifer Doudna and Zhang Feng, had realized that this well understood system of genomic editing can offer insights to explaining the editing of genes in eukaryotic cells that contain a nucleus membrane. This application offered a novel application of CRISPR technologies because knowledge surrounding CRISPR in bacteria cells belonged to a domain of prokaryotic cells that do not have a nucleus membrane. Yet, by drawing on the insights of how CRISPR worked in these prokaryotic cells, Drs. Jennifer Doudna and Zhang Feng discovered a way to apply this base knowledge domain of prokaryotic cells into solving the targeted problems of genomic editing in eukaryotic cells.

2.3 | Social structure: Coherence

While the RAP offers an insight that cannot be explained by the associative learning process of AC research, a firm's AC, however, requires a social structure that connects these learning processes. An organizational concept of coherence (Foss & Christensen, 2001; Leten et al., 2007; Lien & Klein, 2013; Teece et al., 1994) offers such a social structure. Having origins in cognitive and organizational learning research, coherence underscores that a firm is a distributive knowledge system (Foss & Christensen, 2001; Lien & Klein, 2013; Teece et al., 1994) in which elements of this distributed system are connected by a set of relationships that are 'common' to a firm's combined activities (Teece et al., 1994). Teece et al. (1994) describes:

> a firm exhibits coherence if its lines of business are related, in the sense that there are certain technological and market characteristics common to each. A firm's coherence increases as the number of common technological and market characteristics found in each product line increases. Coherence is thus a measure of relatedness. A corporation fails to exhibit coherence when common characteristics are allocated randomly across a firm's line of business (p. 4).

The 'common' aspects of a firm's coherence underscore that members/units of a firm have a shared understanding of those exchanges that are common amongst a firm's combined business activities. This common understanding has been the basis for explaining a firm's diversification where studies show that coherent firms diversify into experiences that are common to its business activities (Foss & Christensen, 2001; Leten et al., 2007; Lien & Klein, 2013; Teece et al., 1994). While the focus of coherence research has been on a firm's diversification, coherence also emphasizes an assimilation of external activities that are closely related to a firm's combined experiences (Leten et al., 2007; Teece et al., 1994). For instance, Teece et al. (1994) study found that a firm with a coherent knowledge structure assimilates external information that strengthens or reinforces the common relationships amongst a firm's combined elements. Yet, since a firm's assimilation of external information depends on its members' cognition, the cognitive origins of these common relationships however have not been explained (Foss & Christensen, 2001; Leten et al., 2007; Lien & Klein, 2013; Teece et al., 1994).

To explain the cognitive foundations of a firm's coherent social structure, its common relations or common relational associations are attributed to the aggregate structural mappings of its members (Foss & Christensen, 2001; Lien & Klein, 2013). This aggregation introduces a competitive process where each member competes by making inferences about whether the external solutions of a base domain can be related to solving the problems of a firm's target domain. Individuals who succeed in identifying a relational association between their base–target domains are more likely to combine these knowledge domains over those associations that do not. This is because according to coherence research, the competitive process is subject to a ‘survivor principle’ where efficient combinations of activities are selected over those that are less efficient (Lien & Klein, 2013; Teece et al., 1994). This survivor principle also suggests that efficient combinations of knowledge activities are more likely to be recombined and reproduced by other members, because they have greater survival prospects over other combinations of knowledge activities (Lien & Klein, 2013). As a result, individuals who succeed in identifying a relational association between their base–target domains will have their combinations of knowledge activities reproduced by other members. This reproduction creates a common or shared understanding of these relational associations.

By drawing on these common relational associations, the individual's RAP not only promotes a shared understanding of these relational associations, but it also reinforces the individual member's RAP to make inferences about its external information environment. This mutual reinforcement improves the communication of analogies amongst a firm's members to which increases a member's RAP to form analogical inferences to other parts of a firm's information environment. This self-reinforcing process can yield a set of overlapping experiences where the individual's RAP is mutually reinforced by the firm's coherent knowledge structure. Behavioural researchers would argue that these common or shared relational associations would promote redundant and myopic knowledge exchanges.

While these are valid concerns, these arguments do not account for the ‘polysemous’ property of analogies (Bowdle & Gentner, 2005). This polysemous property finds that analogies are subject to multiple interpretations and that these interpretations are applied in ways specific to a targeted problem (Bowdle & Gentner, 2005; Hargadon & Bechky, 2006; Hargadon & Sutton, 1997). This polysemous property suggests that the shared understandings in the firm's coherence require that individuals draw on their specialized expertise to apply these understandings in ways that fit the salient features of their targeted problem. For instance, in Hargadon and Sutton's (1997) study of IDEO, they observed that IDEO had a collection of ‘shared cool’ technologies. These shared technologies served as a common pool of analogies that enabled designers to solve the technical problems in different industries (see also Christensen & Schunn, 2007; Hargadon & Bechky, 2006; Kalogerakis et al., 2010). But to apply this shared understanding, engineers had to draw on their design expertise to re-interpret these shared understandings to fit the problems faced by their targeted industry (Hargadon & Bechky, 2006).

As a result, since a firm's coherence is rooted in a shared understanding of analogies, these analogies exhibit a polysemous property that does not constrain its members to self-similar or myopic experiences. But instead enables its members to develop new interpretations of these shared understandings in solving its targeted problems. In defining this coherence, a firm's coherence refers to a set of common relational associations in which the shared understanding of these relational associations (i.e., shared understanding of analogies) enables a firm's members to relate the external solutions of a base domain to solving the problems of a firm's target domain.

2.4 | Coherence: AC and innovative performance

By drawing on the common relational associations of a firm's coherence, a firm's coherence offers an AC that increases its members' ability to ‘recognize, assimilate, and exploit’ external experiences. In explaining the components of this AC, recognition involves a capacity to explore and identify the value of external information (Todorova & Durisin, 2007; Zobel, 2017). This recognition leverages a firm's coherence where its common relational associations enable its members to recognize whether the solutions of an external environment can be structurally mapped into solving a firm's targeted problem. Specifically, when these external solutions involve a base domain that is included in a firm's common relational associations, members can make analogical inferences about the relevance of these external solutions in solving the firm's targeted problems. In contrast, for those external solutions that are not included in a firm's common relational associations, these base solutions cannot be structurally mapped into solving the firm's targeted problems, and therefore, members cannot recognize the value of these external solutions to the firm. Hence, unlike AC research, the recognition of the value of external knowledge is not based on its similarity to an individual's experiences or cognitive schemas (Cohen & Levinthal, 1990; Lane & Lubatkin, 1998; Schildt et al., 2012; Todorova & Durisin, 2007). But rather, the value of this external knowledge is recognized because the external solutions of a base domain can be structurally mapped by a firm's common relational associations. This is consistent with analogical research that finds members draw on analogies from a ‘coherent knowledge structure’ when information in the base domain shares a ‘common’ relational association with this knowledge structure (Gentner & Colhoun, 2010; Gentner & Markman, 1997).

By recognizing the value of these external solutions, common relational associations assimilate these external solutions into a member's experiences. Assimilation involves understanding and disseminating the value of external knowledge within a firm's internal experiences (e.g., Kostopoulos et al., 2011). Common relational associations offer an assimilation in which the external solutions of a base domain are diffused amongst members because these solutions can be structurally mapped into solving a member's targeted problems. Hence, unlike Todorova and Durisin (2007), this assimilated information is not governed by an individual's cognitive schemes but by a competitive process where analogies are assimilated because they solve an individual's targeted problem. This assimilation reinforces the relatedness found amongst the common relational associations of a firm's coherence. These common relational associations are used in subsequent periods to assimilate other external solutions that can be structurally mapped by these relational associations. As a result, these common relational associations offer an assimilation process in which the base–target relationships not only solve a member's targeted problems, but that the adoption of these base–target relationships reinforces a shared understanding of common relational associations. This is consistent with AC research that finds social interactions promote a shared understanding of norms and an assimilation of external information that reinforces the firm's shared understandings (e.g., Engelman et al., 2017; Jansen et al., 2005; Kang & Lee, 2017; Zhao et al., 2020).

Common relational associations also promote an exploitation of the externally assimilated information. Exploitation refers to an application in which the value of external knowledge is leveraged into extending and refining a member's specialized experiences or skills (Todorova & Durisin, 2007; Zahra & George, 2002; Zobel, 2017). Specifically, since common relational associations or shared understandings lack specificity in addressing a firm member's targeted problem (i.e., polysemous property), individuals exploit these relational associations by drawing on their unique or specialized understandings of their targeted problem (see also Hargadon & Sutton, 1997). By exploiting a member's unique understandings, members are not only more likely to structurally map the external solutions to solving their firm's targeted problems, but this structural mapping offers an exploitation that efficiently recombines a firm's external/internal experiences. In particular, as a firm's coherent structure involves leveraging the specialized expertise of its members (Foss & Christensen, 2001; Lien & Klein, 2013; Teece et al., 1994), this coherence introduces an exploitation where the firm's assimilated solutions are transformed by the specialized expertise of its members. This exploitation is consistent with Božič & Dimovski's (2019) Business Intelligence Analytics (BIA) study. They find that in order to fully exploit the firm's BIA assets (i.e., computer systems that support the collection, analysis and dissemination of data), the assimilated data had to be re-interpreted by their data experts who had specialized understanding of their firm's business activities. This specialized understanding enabled these data experts to transform the assimilated data into new understandings about their firm's value creation activities. This suggests that, unlike Todorova and Durisin (2007), coherence introduces an exploitation where assimilation and transformation cannot be treated as separate learning processes.

As the common relational associations of a firm's coherence enable the recognition, assimilation and exploitation of external information, this coherence increases a firm's innovative performance. According to AC research, a firm's innovative performance is attributed to a recombination external/internal experiences that offer commercially valued uses (Cohen & Levinthal, 1990; Kostopoulos et al., 2011; Todorova & Durisin, 2007; Zahra & George, 2002). A firm's coherence offers 'coordination efficiencies' (Foss & Christensen, 2001) that promote this recombination. These coordination efficiencies refer to a 'capacity to generate and exploit what may be called the economies of diversity' (Foss & Christensen, 2001, p. 222). Foss and Christensen (2001) argue that these coordination efficiencies are an important feature of a coherent social structure because by leveraging the economies of diversity, a coherent structure 'increases the probability of making new combinations' (p. 222). This study argues that these coordination efficiencies are attributed to the common relational associations of a firm's coherence. These common relational associations coordinate a firm's members' experiences by promoting a shared understanding of analogies. This shared understanding increases its members' ability to recognize and assimilate the external solutions of a base domain and to exploit these external solutions by leveraging each member's unique understandings of their firm's targeted problems. As insight involves a structural mapping of these base–target domains, these common relational associations offer a shared understanding that recombines the experiences in these base–target domains. This recombination not only produces insight into solving the firm's targeted problems, but by solving these problems, this insight reveals the commercial value of a firm's combined activities. Hence, since common relational associations are a central feature of a firm's coherent social structure, a firm's coherence produces an insight that impacts its innovative performance.

Hypothesis H1. A firm's coherence has a positive influence on its innovative performance.

Analogical studies have shown that a member's unique analogical inferences can also be a source of insight to a firm's innovative performance (Dahl & Moreau, 2002; Gassmann & Zeschky, 2008; Kalogerakis et al., 2010). Unique analogical inferences occur when individuals draw on solutions from 'distant' base domains to solving their targeted problems (Dahl & Moreau, 2002; Gassmann & Zeschky, 2008; Kalogerakis et al., 2010). Analogical studies have found that the greater is this distance, the greater is an individual's ability to discover novel solutions (Dahl & Moreau, 2002; Gassmann & Zeschky, 2008; Kalogerakis et al., 2010). Such analogical inferences have been described as 'out of the box thinking' in which individuals/inventors seek unconventional solutions to technical design problems. For instance, design engineers at Nike recognized that the suspensions found in formula race cars can offer shock absorption characteristics that can be applied to their shoe designs (Kalogerakis et al., 2010). Kalogerakis et al.'s (2010) argue that these unique analogical inferences can play an important role in AC research (see also Enkel & Heil, 2014) because analogies formed across distant base–target domains can increase a firm's ability to assimilate distant knowledge experiences (see also Müller et al., 2021).

Although these unique analogical inferences have been recognized in AC research (Enkel & Heil, 2014; Kalogerakis et al., 2010; Müller et al., 2021), an understanding of the social structural properties surrounding such inferences remains limited. For instance, Engelman et al. (2017) argue that social integration mechanisms can promote the identification of distant technologies and that this identification can increase a firm's PACAP to explore new market trends. However, with the possible exception of (Enkel & Heil, 2014), an understanding of the individual learning processes responsible for this social structure remains unspecified (see also Müller et al., 2021; Yao & Chang, 2017). This study argues that, through the RAP, unique analogical inferences introduce distant base–target relationships that can impact a firm's social structure. This is because since a member's unique analogical inferences expose a firm to distant base–target relationships (Dahl & Moreau, 2002; Gassmann & Zeschky, 2008; Kalogerakis et al., 2010), these relationships increase the diversity of a firm's social connections. This greater diversity enables members to engage in their own unique analogical inferences. By exposing members to distant base–target relationships, each member can then learn from the distant experiences of their connected members in solving their own targeted problems. As individuals learn from the unique analogical inferences of others, these exchanges develop an increasingly unique or diverse social network structure (see also Enkel & Heil, 2014). This unique social network is consistent with Enkel & Heil's (2014) study, who argued that distant analogical inferences can promote a greater diversity of social connections. However, unlike their study, a member's unique analogical inferences not only introduce a unique or diverse social structure, but that this social structure also develops a firm's AC to recognize, assimilate and exploit distant external knowledge.

To elaborate, a firm's unique social structure offers a recognition that appeals to a firm's explorative search (e.g., Enkel & Heil, 2014). According to AC research, Enkel and Heil (2014) describe that an exploration of distant partner experiences increases a firm's ability to recognize external experiences not recognized by a locally connected group. Specifically, while both coherent and unique social structures emphasize a relatedness between a base–target domain, a unique social structure offers an exploration that leverages the distant aspects of relatedness. With this distinction, a unique social structure offers an exploration of distant base solutions that cannot be recognized by the common relational associations of a firm's coherence. This is because these common relational associations can only recognize those base solutions that can be structurally mapped by these associations. As a result, a unique social structure offers an exploration that increases a firm's ability to recognize distant base solutions that cannot be recognized by the common relational associations of a firm's coherence.

By recognizing the value of these distant solutions, a unique social structure emphasizes an assimilation that increases the diversity of its internal connections. This assimilation of distant base solutions introduces opportunities to develop new associations to a firm's targeted problems. These associations offer alternative ways to recombine distant base–target relationships and thus increase the diversity of connections in a firm's unique social structure. This greater diversity then increases a member's ability to form unique analogical inferences to other distant base–target relationships and thus reinforces the diversity of connections in a firm's unique social structure. This yields an assimilation process in which the assimilation of distant base–target relationships reinforces members' unique analogical inferences. Thus, unlike the common relational associations of a firm's coherence, a unique network structure offers an assimilation that promotes a diverse rather than a shared understanding of analogies. This assimilation also differs from Todorova and Durisin's (2007) explanations where members of a unique network are no longer confined to an assimilation of experiences that are consistent with their cognitive schemes. For instance, Ferraris et al.'s (2020) AC study found food companies sought partnerships with creative industries because they offered new ways to market their food products (see also Akram et al., 2020).

Last, a unique social structure promotes an exploitation in which distant base solutions are recombined with a firm member's specialized experiences. By engaging in this recombination, members can exploit their specialized expertise in ways not previously envisioned (see also Ferraris et al., 2020). This exposure to distant solutions offers new perspectives that can re-cast a member's expertise in a different light (Hargadon & Bechky, 2006; Kannan-Narasimhan & Lawrence, 2018). This re-casting is consistent with Hargadon and Bechky (2006) notion of ‘reframing’ in which an exposure to new information fundamentally re-examines an individual's underlying assumptions and mental models. Studies find this reframing offers opportunities to exploit a firm's assets/resources in ways not previously considered (Belso-Martínez et al., 2019; Kannan-Narasimhan & Lawrence, 2018; Müller et al., 2021). For instance, Müller et al.'s (2021) German manufacturing study found that the assimilation of new knowledge experiences yielded a critical reassessment of the firm's business activities. This reassessment resulted in transforming their firm's business model where new business activities were developed to better serve their customer needs (see also Belso-Martínez et al., 2019; Kannan-Narasimhan & Lawrence, 2018; Tzokas et al., 2015). This reframing is also consistent with Kannan-Narasimhan and Lawrence's (2018) study, which finds exposure to different discourse can re-conceptualize or reframe the valued uses from an organization's resources (see also Belso-Martínez et al., 2019). As uniqueness exposes its members to distant experiences, uniqueness introduces an exploitation where the assimilation of ‘distant’ information offers a transformation that reframes the firm's understanding of its target problem. Hence, like coherence, this exploitation suggests that a firm's assimilation cannot be separated from its transformation.

By drawing on the recognition, assimilation and exploitive properties of this unique social structure, a unique social structure increases a firm's innovative performance. This unique social structure leverages members' unique analogical inferences to recognize and assimilate distant knowledge sources and to exploit this distant knowledge by reframing members' understandings of their firm's targeted problems. Through these processes, a unique network structure offers a reframing where distant experiences are recombined with a members' specialized expertise to solve targeted problems in ways not previously envisioned by the member's expertise. As result, a unique social structure develops insights that reveal new commercial applications or valued uses from this recombination of distant experiences and thus impacting a firm's innovative performance.

Hypothesis H2. A firm's unique social structure has a positive influence on its innovative performance.

3 | METHODS

3.1 | Data and sample

As longitudinal studies are scarce in AC research (Chen & Chang, 2019; Enkel et al., 2018; Kang & Lee, 2017; Song et al., 2018; Yao & Chang, 2017), a panel data set was developed for a sample of US biotechnology firms. The US biotechnology market (Lane & Lubatkin, 1998) was chosen because it is widely recognized for its propensity to innovate. The Bioscan database was used to identify this study's sample of biotechnology firms in which this sample was used to collect patent application data from the United States Patent and Trade Office (USPTO). While patent application data have been used in a variety of innovation (Hall et al., 2001; Kostopoulos et al., 2011)—as well as AC—studies (Jo et al., 2016; Schildt et al., 2012; Vasudeva & Anand, 2011), few studies have used patent application data to examine the RAP (Dahl & Moreau, 2002; Jeong & Kim, 2014; Lin et al., 2012). This study's patent data offers an examination of this RAP in a panel setting. In addition to this patent data, financial data involving a biotechnology firm's revenue and R&D expenditures (in US$) were collected from the Mergent database. The USPTO patent application and Mergent financial data were then consolidated at the firm level.

A sample of 1,759 firm observations covering a sample period from 1987 to 2005 (19 years) was available for empirical examination. This sample period was chosen to capture the biological advances during this period (Linton et al., 2008). Specifically, according to a 2008 USPTO report (Linton et al., 2008), advances in biological sciences during the earlier 1980s allowed for the genetic manipulations of micro-organisms. These micro-organisms were used to produce biocatalysts that had various commercial applications to the chemical and pharmaceutical industries. With these genetic advances, the late 1980s and early 1990s experienced a period of growth where the number of awarded patents grew from approximately 3,500 in 1993 to just under 9,000 patents in 1999 and, by 2005, declined to a little over 6,000 patents (Linton et al., 2008). The advantage of this study's sampling -1987–2005- period is that it captures this full life cycle of patent activity. This is important because studies that do not capture this full lifecycle can lead to an over or under reporting of patent activities and thus can impact the innovative findings of the AC concept. One disadvantage however is that the validity of this study's findings highly depends on its sampling period.

3.2 | Dependent variable

As AC focuses on the firm's ability to commercialize its inventions (Cohen & Levinthal, 1990; Song et al., 2018; Todorova & Durisin, 2007; Zahra & George, 2002), this ability has been found to impact the firm's innovative performance (Maldonado et al., 2019; Xie et al., 2018). AC studies have drawn on a firm's number of patent applications and forward patent citations to measure the firm's innovation performance (Kostopoulos et al., 2011; Song et al., 2018; Vasudeva & Anand, 2011). This study chose a firm's forward patent citations because they reflect a measure of originality and have been strongly correlated with a firm's commercial success (Jaffe & de Rassenfosse, 2017; Trajtenberg, 1990). For instance, studies find forward citations have been related to improvements in technology and have been associated with the firm's commercial value (Jaffe & de Rassenfosse, 2017; Verhoeven et al., 2016). This suggests that firms that receive a greater number of forward patent citations are more likely to exhibit a greater degree of newness and disruption, because their commercial success is likely to have a greater impact in spawning new technological advances (Jaffe & de Rassenfosse, 2017; Verhoeven et al., 2016). However, as the focus of AC research is on the firm's commercialization of external ideas, rather than their disruption (Zou et al., 2018), the firm's forward patent citations were used to measure this commercialization. Furthermore, since patents are often built on the technical achievements of others (i.e., prior technological art) (Hall et al., 2001; Ng et al., 2019), a firm's patent inventions are the result of recombining these external technical achievements within a firm's internal scientific expertise (see also below). Hence, a firm's forward patent citations not only measure the commercial value of a firm's patent inventions, but it also measure the commercial value of these combined technical experiences. With these considerations, the firm's forward patent citations, *Pat_Cit*, are measured by the annual number of citations received by the firm's patent applications in its patent portfolio.

3.2.1 | Coherence

Coherence is defined at the level of a firm's patent portfolio and is measured by modifying a methodology developed by Leten et al. (2007). In defining a firm's patent portfolio, it consists of K patent applications submitted by the patent applicants/inventors of the firm. Each patent applicant is tasked with a target problem of developing a novel invention that offers a practical/commercial solution that is non-obvious. According to USPTO law, solutions to this target problem require a search of the patent application's 'prior technological art' (Ng et al., 2019). This 'prior art' refers to the cited patents in which a patent application is built upon (Hall et al., 2001; Ng et al., 2019). In analogical terms, these cited patents constitute the patent application's 'base domain' where this base domain offers a set of external technological solutions used in solving the technical problems targeted by the invented patent.

To construct these knowledge domains (see also Lin et al., 2012; Schildt et al., 2012), we designate the base, *j*, (i.e., cited patents) and target, *i*, (i.e., patent inventions) domains by the vectors O_j and O_i, respectively. According to the USPTO, cited, *j*, and invented patents, *i*, are assigned to one of 400+ USPTO patent technology classes. We assigned these technology classifications to each of the elements of the base, O_j, and target, O_i, domain vectors. Specifically, in defining the *k*th element within the target domain vector, O_i, we let $O_{ik} = 1$ if a firm's invention in patent application *k* is assigned to a technology class *i*. Similarly, for the base domain vector, O_j, we let $O_{jk} = 1$ if a firm's invention in patent application *k* references a cited patent in a technology class *j*.

To measure the relational associations formed between the base, O_j, and target, O_i, domain vectors, a joint occurrence matrix, O_{ij}, was computed (see also Christensen & Schunn, 2007; Dahl & Moreau, 2002; Dunbar, 1997; Kalogerakis et al., 2010). This joint occurrence matrix, O_{ij}, measures the number of times in which technology classes of a base, *j*, and target, *i*, domain jointly occur. Analogy researchers have used a similar measure in which the greater is this joint occurrence, the greater is the extent to which base solutions in technology class, *j*, are being structurally mapped to the target domain, *i* (see also Dahl & Moreau, 2002; Dunbar, 1997).

$$O_{ij} = \sum_k O_{ik} O_{jk}, \tag{1}$$

where $O_i = \sum_j O_{ij}$.

Yet, since these joint occurrences, O_{ij}, can occur because of random chance, this joint occurrence, O_{ij}, matrix is compared to the expected likelihood that their joint occurrences would have occurred from random chance alone (see also Teece et al., 1994). In drawing on Leten et al. (2007), an expected random joint occurrence, E_{ij}, was computed by taking the total number of occurrences for each patent application in class *i*, O_i, and weighting this vector by the number of cited patents classified in class *j*, N_j, over the total number of patent citations, $T = \sum_j N_j$.

$$E_{ij} = O_i \frac{N_j}{T} \tag{2}$$

A relatedness, R_{ij}, matrix was then constructed where the sum of the symmetric elements of the observed joint occurrence matrix, $O_{ij} + O_{ji}$, is divided by the respective sum of the symmetric elements of the expected random joint occurrence matrix, $E_{ij} + E_{ji}$.

$$R_{ij} = \left[\frac{O_{ij}, + O_{ji},}{E_{ij} + E_{ji}}\right], \tag{3}$$

where $R_{ij} = R_{ji}$.

The challenge with this relatedness, R_{ij}, matrix is that Leten et al. (2007) and other coherence studies (Lien & Klein, 2013; Nesta & Saviotti, 2005) assume that the elements of this relatedness, R_{ij}, matrix are symmetric, where $R_{ij} = R_{ji}$. Yet, since a patent application cannot influence a previously cited patent, this symmetry is inconsistent with the analogical reasoning process. An asymmetric technological relational association, R^*_{ij}, is instead proposed where the symmetric components of this measure were excluded.

$$R^*_{ij} = \left[\frac{O_{ij}}{E_{ij}}\right] \tag{4}$$

This asymmetric relational association matrix, R^*_{ij}, is then weighted by the total number of cited patents, N_j, in class *j*, to the total number of cited patent classes in a firm's patent portfolio, $\sum_{i \neq j} N_j$. This yields a weighted average relatedness, WAR_i, measure. WAR_i measures the relational associations between a patent application class in target domain *i* to all other cited reference classes in the base domain *j* (Leten et al., 2007; Nesta & Saviotti, 2005).

$$WAR_i = \frac{\sum_{i \neq j} R^*_{ij} N_j}{\sum_{i \neq j} N_j} \tag{5}$$

A firm's coherence, *Coherence*, is then computed by aggregating the weighted average relational measure, WAR_i, across all the patent application classes in the target domain *i*. An increase in the value of this coherence measure, *Coherence*, indicates an increasing degree of relatedness amongst the patent classes of a firm's patent application portfolio. The greater is this relatedness, the greater is the likelihood that the relational associations in a firm's coherence share a common relational association (see also Teece et al., 1994).

$$Coherence = \sum_i \left[WAR_i \frac{P_i}{\sum_i P_i}\right] \tag{6}$$

3.2.2 | Uniqueness

A firm's unique social structure is measured by aggregating elements of the asymmetric relational association matrix, R^*_{ij}. Each of these elements measures the distance between the technological classes of the base–target domains. However, since a unique social structure involves only distant base–target relationships, these distances are measured by aggregating only those relational elements that do not share the same technology class. Studies by Jo et al. (2016), Lin et al. (2012) and Schildt et al. (2012) have used a similar distinction to measure the technology distance between these domains. To develop this study's distance measure, the distant base–target relations of a firm's unique social structure are measured by Equation (7). The greater is this value, the greater is the distance in which distant knowledge is being structurally mapped across a firm's base and target domains, and thus the greater is the uniqueness in a firm's social structure (see also Jo et al., 2016; Lin et al., 2012; Schildt et al., 2012).

$$Uniqueness = \sum_i \sum_j R^*_{ij}, \tag{7}$$

where $i \neq j$.

3.2.3 | Control variables

In explaining this study's controls, a firm's *R&D Intensity* is commonly used to measure a firm's AC (Song et al., 2018; Zou et al., 2018). A firm's *R&D Intensity* is computed by taking the ratio of a firm's R&D expenditures to its revenues. Due to its skewness, the log of this *R&D Intensity* variable was used. As a firm's diversity of experiences influences its AC, a firm's diversity of experiences (e.g., Cohen & Levinthal, 1990; Schildt et al., 2012), *DIV*, is measured by the diversity of patent classes in the firm's patent portfolio (Jaffe & de Rassenfosse, 2017; Vasudeva & Anand, 2011). This diversity was computed by a Herfindahl–Hirshman Index (Vasudeva & Anand, 2011). A firm's cumulative number of patents applications, *Cum_Pat*, was included to account for path dependent effects in the AC process and is measured by aggregating the cumulative number of patent applications filed by a firm over each sampling period (see also Ng et al., 2019; Ng & Sanchez-Aragon, 2021; Schildt et al., 2012). AC research also finds that a firm's appropriation regime can influence a firm's AC (Chen & Chang, 2019; Cohen & Levinthal, 1990; Ng & Sanchez-Aragon, 2021; Todorova & Durisin, 2007; Zahra & George, 2002). This appropriation regime is measured by aggregating—for each sample period—the annual number of patent claims made by all firms, *PRights*, in the sample (Ng et al., 2019; Ng & Sanchez-Aragon, 2021). In addition, a time trend, *Trend*, was included because patent citation data is vulnerable to truncation problems (Hall et al., 2001). Lastly, Thornhill (2006) study showed that an industry's dynamism can influence a firm's opportunity to innovate. An industry's dynamism, *Dynamism*, is measured by aggregating—for each sample period—the R&D expenditures of all firms in the sample (Jo et al., 2016; Thornhill, 2006).

3.3 | Econometric approach

To control for firm level sources of heterogeneity, fixed effect (FE) Poisson and negative binomial panel estimators are commonly used in estimating patent-based outcomes (Jo et al., 2016; Nesta & Saviotti, 2005; Ng et al., 2019; Trajtenberg, 1990). In panel studies, a common approach is to use the conditional FE negative binomial model, because it adds a parameter value that allows for over-dispersion. However, Allison and Waterman (2002) find that FE negative binomial models do 'not accomplish what is usually desired in a fixed-effect method' (pp. 263–264). They showed that by including the over-dispersion parameter in the likelihood function, it does not condition out the individual FEs and can produce inconsistent estimates. These authors proposed that a FE Poisson model that adjusts for the standard errors for over-dispersion can be used. To adjust for this over-dispersion, Wooldridge (1999) showed that a FE Quasi-Maximum Likelihood (QML) Poisson estimator can produce consistent estimates (see also Ng et al., 2019). For robustness, the FE negative binomial and FE QML Poisson estimations involving the respective xtnbreg and xtpqml commands of the Stata 16 statistical package were used.

While over dispersion problems have been addressed by FE negative binomial and FE QML Poisson estimations, the challenge with these estimations is that they do not control for endogeneity. Endogeneity is commonly attributed to an (1) omitted variable, (2) measurement error and/or (3) simultaneity. As this study's concept *Coherence* involves a dynamic process, simultaneity can be a potential problem. In that, since a firm's *Coherence* is based on its cited patents, a firm's patent citations of a previous period can influence a firm's patent inventions to cite those that have cited its patents and thus influence a firm's *Coherence*. A failure to control for this reverse causality could cause a simultaneity problem where the error term will be correlated with the *Coherence* variable.

To account for this endogeneity, an instrumental variable (IV) approach was used. An instrument, *Z*, has the property where it is correlated with the endogenous variable(s), but is independent of the error term (Wooldridge, 2010). A firm's one period lagged coherence, $Coherence_{t\text{-}1}$, is used as an instrument, *Z*, for the endogenous, *Coherence*, variable. This is because since a firm's shared understanding influences its present understandings, a firm's $Coherence_{t\text{-}1}$, in period $t-1$ is likely correlated with its $Coherence_t$ in period *t*. Furthermore, since the previous period, $Coherence_{t\text{-}1}$, does not affect the error term of the current period, *t*, the $Coherence_{t\text{-}1}$ variable should be exogenous and therefore offer a suitable instrument to the endogenous *Coherence* variable. While this may appear to be a reasonable justification, the use of a lagged instrument is problematic in a FE panel setting. FE panel estimates do not allow the use of a lagged dependent variable because the lagged dependent variable is correlated with the error term. Dynamic panel models involving the use of the Arellano–Bond (Arellano & Bond, 1991) estimator have been developed to resolve this type of endogeneity problem.

In using a GMM approach, an attractive feature of the Arellano–Bond estimator is that a set of lagged dependent and/or lagged independent variables can be used as instruments for dependent and independent variables. This feature can be used in controlling for simultaneity bias. In particular, since a firm's *Coherence* can be influenced by both its $Coherence_{t\text{-}1}$ (i.e., shared understandings of a past period) and $Pat\_Cit_{t\text{-}1}$ (i.e., simultaneity), the Arellano–Bond estimator can be used to control for the endogeneity surrounding this dynamic process. Specifically, the Arellano–Bond estimator utilizes the first differences of the panel data to remove the time-invariant FE. The lagged variables constitute legitimate instruments if their residuals are free from second-order serial correlation (Arellano & Bond, 1991). In

TABLE 1 Descriptive statistics and correlations.

Variables	Mean	Std. dev.	1	2	3	4	5	6	7	8
(1) Pat_Cit	116.2	845.78								
(2) Dynamism	1.36E+11	7.80E+10	−0.1862							
(3) Cum_Pat	197.52	1,435.89	0.522	0.0001						
(4) PRights	95,008.42	43,674.17	−0.1792	0.6747	−0.0274					
(5) Trend	9	5.48	−0.2708	0.5996	0.0234	0.5731				
(6) log(R&D intensity)	−0.2	2.3	−0.2377	−0.0043	−0.2637	0.024	−0.0141			
(7) DIV	0.39	0.34	0.3719	−0.0165	0.3282	−0.0198	−0.0095	−0.2803		
(8) Coherence	0.41	0.27	0.0477	0.049	0.0206	0.0751	0.0687	0.0876	0.1453	
(9) Uniqueness	208.38	2,150.06	0.6584	−0.0109	0.8225	−0.0201	−0.0034	−0.2695	0.3466	0.0095

using the xtabond2 command in Stata 16, the firm's $Coherence_t$ is regressed on the $Pat\_Cit_{t\text{-}1}$ and $Coherence_{t\text{-}1}$ variables where the second and third lagged values of these variables were used as their instruments. This estimation includes all the control variables specified in our models where the *Trend* variable was treated as exogenous. In using the Arellano–Bond test for serial correlation, the serial correlation for the second order differences (AR2) (Prob. > $z = 0.453$) were not significant. This test indicates that the second and third period lags for the *Coherence* - $Coherence_{t\text{-}2}$ and $Coherence_{t\text{-}3}$ - and *Pat_Cit* - $Pat\_Cit_{t\text{-}2.}$ and $Pat\_Cit_{t\text{-}3}$ -variables were valid instruments in our model.

In using the logic of a 2SLS approach, the endogenous *Coherence* variable in our FE negative binomial and QML Poisson models is replaced by the predicted coherence, *Pred_Coherence*, values of the Arellano-Bond estimation. Yet, since the 2SLS procedure is based on an extension of OLS, we are not aware of any available 2SLS approach that can be applied to a count estimation procedure. One approach is to use a control function (CF) approach (Wooldridge, 2010) where the predicted residuals from the Arellano–Bond estimations—*resid*—are included as a regressor in the second stage count estimations. Significant values for the predicted residuals indicate the residuals are controlling for the endogeneity. We use this CF approach to estimate the FE Negative binomial and QML Poisson models in the second stage.

4 | RESULTS AND DISCUSSIONS

The descriptive statistics and correlations are shown in Table 1. Of particular interest in Table 1 is the forward patent citation, *Pat_Cit*, variable has a mean of 116.2 and a standard deviation of 845.78. This suggests that a problem of over dispersion is present and thus warranted the use of this study's proposed approach. With respect to the correlation matrix, there were high correlations amongst some of the independent variables. A VIF test was conducted. The average VIF scores for all variables were 1.95, and the VIF scores for the highly correlated variables, *Dynamism*, *PRights*, *Trend Cum_Pat* and *Uniqueness*, were, respectively, 2.1, 2.01, 1.71, 3.14 and 3.18. As these VIF scores were less than the recommended value of 10, multi-collinearity does not appear to be an issue (Wooldridge, 2010).[1] Table 2 reports the FE estimates for the negative binomial (models 1–4) and QML Poisson (models 5–8) models. By drawing on this study's 2SLS CF approach, the Arellano–Bond estimator of the FE negative binomial (models 1–4) and FE QML Poisson (models 5–8) models are reported in table 3.

4.1 | Control variables

In explaining the estimates on the control variables in Table 2, the industry *Dynamism* was negative and significant in models 5 ($\beta = -1.04\text{e-}12^*$, $p < .1$) and 7 ($\beta = -9.49\text{e-}13^*$, $p < .1$). These findings do not support Thornhill's (2006) arguments. A firm's cumulative patent, *Cum_Pat*, was positive and significant in models 1 ($\beta = 1.09\text{e-}$

TABLE 2 FE negative binomial (models 1–4) and QML Poisson estimates (models 5–8).

Variables	1	2	3	4	5	6	7	8
Dynamism	−5.1e-13	−5.27e-13	−5.5e-13	−5.6e−13	−1.04e-12*	−6.47e-13	−9.49e-13*	−5.99e-13
	(4.64e-13)	(4.57e-13)	(4.58e-13)	(4.52e-13)	(6.21e-13)	(6.03e-13)	(5.50e-13)	(5.37e-13)
Cum_Pat	0.000109***	0.000114***	−4.02e-05	−3.00e-05	9.36e-05***	9.42e-05**	−7.97e-05	−6.34e-05
	(1.99e-05)	(1.93e-05)	(3.48e-05)	(3.43e-05)	(3.05e-05)	(3.72e-05)	(5.02e-05)	(5.29e-05)
PRights	8.28e-06***	7.97e-06***	7.87e-06***	7.55e-06***	1.35e-05***	1.23e-05***	1.24e-05***	1.14e-05***
	(7.59e-07)	(7.53e-07)	(7.58e-07)	(7.53e-07)	(1.13e-06)	(1.08e-06)	(1.12e-06)	(1.06e-06)
Trend	−0.178***	−0.182***	−0.176***	−0.179***	−0.230***	−0.234***	−0.218***	−0.223***
	(0.00711)	(0.00709)	(0.00696)	(0.00695)	(0.0134)	(0.0135)	(0.0144)	(0.0143)
Log(R&D Intensity)	−0.00145	−0.00932	−0.00843	−0.0155	0.0912**	0.0722*	0.0875**	0.0695*
	(0.0131)	(0.0131)	(0.0131)	(0.0132)	(0.0374)	(0.0384)	(0.0378)	(0.0385)
DIV	1.364***	1.302***	1.386***	1.324***	1.158***	0.959***	1.067***	0.887***
	(0.0722)	(0.0723)	(0.0721)	(0.0723)	(0.224)	(0.192)	(0.223)	(0.191)
Coherence		0.453***		0.441***		1.201***		1.134***
		(0.0650)		(0.0649)		(0.161)		(0.171)
Uniqueness			0.000155***	0.000148***			0.000136***	0.000126***
			(2.40e-05)	(2.38e-05)			(4.09e-05)	(4.16e-05)
Constant	0.769***	0.696***	0.811***	0.738***				
	(0.0744)	(0.0752)	(0.0740)	(0.0748)				
Observations	2,176	2,176	2,176	2,176	2,176	2,176	2,176	2,176
AIC	17,136.26	17,093.17	17,096.19	17,055.43	127,158.59	117,977.44	120,448.17	112,236.03
BIC	17,170.37	17,132.96	17,135.99	17,100.92	127,187.02	118,011.55	120,482.29	112,275.82

Note: Dependent variable: *Pat_Cit*. Standard errors in parentheses.
***$p < .01$.**$p < .05$.*$p < .1$.

TABLE 3 A-B estimators for FE negative binomial (models 1–4) and QML Poisson estimates (models 5–8).

Variables	1	2	3	4	5	6	7	8
Dynamism	7.17e-13	−8.79e-13*	7.21e-13	−9.28e-13*	−5.62e-13	−9.18e-13	−5.21e-13	−8.00e-13
	(0.144)	(0.073)	(0.138)	(0.056)	(0.358)	(0.140)	(0.338)	(0.148)
Cum_Pat	6.59e-05***	0.000136***	−6.63e-05*	−2.48e-06	8.17e-05**	0.000134***	−7.48e-05	−3.09e-05
	(2.11e-05)	(1.99e-05)	(3.61e-05)	(3.46e-05)	(3.81e-05)	(4.90e-05)	(5.35e-05)	(5.96e-05)
PRights	9.75e-06***	7.13e-06***	9.47e-06***	6.62e-06***	1.33e-05***	9.81e-06***	1.23e-05***	9.57e-06***
	(8.27e-07)	(8.30e-07)	(8.27e-07)	(8.34e-07)	(1.13e-06)	(1.99e-06)	(1.10e-06)	(2.09e-06)
Trend	−0.166***	−0.191***	−0.163***	−0.188***	−0.235***	−0.246***	−0.224***	−0.232***
	(0.00742)	(0.00769)	(0.00733)	(0.00753)	(0.0136)	(0.0152)	(0.0143)	(0.0155)
R&D Intensity	4.05e-05***	−1.28e-05	4.03e-05***	−1.52e-05	4.40e-05***	−5.50e-05	4.41e-05***	−3.33e-05
	(1.14e-05)	(1.20e-05)	(1.13e-05)	(1.19e-05)	(2.51e-06)	(4.52e-05)	(2.51e-06)	(4.60e-05)
DIV	1.650***	0.861***	1.682***	0.866***	1.081***	0.252	0.986***	0.339
	(0.0822)	(0.105)	(0.0830)	(0.105)	(0.231)	(0.461)	(0.229)	(0.472)
Coherence		3.075***		3.203***		5.983**		4.677*
		(0.281)		(0.280)		(2.723)		(2.781)
resid2	0.429***	−2.588***	0.410***	−2.733***	1.266***	−4.726*	1.189***	−3.494
	(0.0748)	(0.284)	(0.0751)	(0.283)	(0.176)	(2.729)	(0.187)	(2.777)
Uniqueness			0.000138***	0.000145***			0.000126***	0.000123***
			(2.59e-05)	(2.40e-05)			(4.17e-05)	(4.13e-05)
Observations	1,759	1,759	1,759	1,759	1,759	1,759	1,759	1,759
AIC	14,523.77	14,424.34	14,497.63	14,388.93	105,414.62	104,828.75	99,706.59	99,350.91
BIC	14,556.6	14,462.64	14,535.93	14,432.71	105,447.46	104,867.05	99,744.9	99,394.69

Note: Dependent variable: *Pat_Cit*. Standard errors in parentheses.
*p < .1.**p < .05.***p < .01.

TABLE 4 Marginal effects of *coherence* and *uniqueness* on *Pat_Cit*.

Variation	25%	50%	75%	100%
Coherence	0.37281963	0.88463374	1.5872622	2.55184434
Uniqueness	0.06834897	0.14136952	0.21938095	0.30272438

04, $p < .01$), 2 ($\beta = 1.14\text{e-}04$, $p < .01$), 5 ($\beta = 9.36\text{–}05$, $p < .01$) and 6 ($\beta = 9.42\text{e-}05$, $p < .01$). A firm's history of technical achievements appears to have a positive influence on the firm's innovative performance. As a firm's ability to commercialize external information is influenced by the environment's 'property right regime' (Ng & Sanchez-Aragon, 2021; Zahra & George, 2002), *PRights* was consistently positive and significant in all models. The *Trend* variable was negative and significant in all models, and thus, the inclusion of this variable to control for truncation problems was warranted. With respect to a firm's AC, a firm's *R&D Intensity* was positive and significant in models 5 ($\beta = 0.0912$, $p < .05$), 6 ($\beta = 0.0722$, $p < .1$), 7 ($\beta = 0.0875$, $p < .05$) and 8 ($\beta = 0.0695$, $p < .1$). The *DIV* variable was positive and significant in all models. These models support the conclusions of AC research (Cohen & Levinthal, 1990; Volberda et al., 2010).

In explaining our main variables of interest, Table 2 shows that *Coherence* is robust to the FE negative binomial (models 2 and 4) and QML Poisson specifications (models 6 and 8). The coefficient estimate on the *Coherence* variable was positive and significant in models 2 ($\beta = 0.453$, $p < .01$) and 6 ($\beta = 1.201$, $p < .01$). When examining the joint effects of a firm's *Coherence* and *Uniqueness*, *Coherence* was also positive and significant in models 4 ($\beta = 0.441$, $p < .01$) and 8 ($\beta = 1.134$, $p < .01$). These estimates were also examined in Table 3 that controlled for endogeneity. The FE negative binomial Arellano–Bond estimation shows that the *Coherence* variable was positive and significant in models 2 ($\beta = 3.075$, $p < .01$) and 4 ($\beta = 3.203$, $p < .01$). Similarly, for the FE QML Arellano–Bond Poisson estimator, the *Coherence* variable was positive and significant in models 6 ($\beta = 5.983$, $p < .05$) and 8 ($\beta = 4.677$, $p < .10$). It is important to note that while Hypothesis H1 cannot be rejected in Tables 2 and 3, the *Coherence* estimates in Table 3 are considerably larger than those in Table 2. This suggests that estimates that do not correct for endogeneity (e.g., Leten et al., 2007) might underestimate the influence of this variable. In addition, Table 3 shows that a firm's *Coherence* offers a more robust explanation for a firm's innovative performance than the AC's measure of *R&D Intensity*. For instance, when examining models 2, 4, 6 and 8 of Table 3, the coefficient estimate on the *Coherence* variable was consistently positive and significant, while the firm's *R&D Intensity* was not. Like *Coherence*, Tables 2 and 3 show that *Uniqueness* is robust to all model specifications. In Table 2, the FE negative binomial models 3 ($\beta = 1.55\text{e-}04$, $p < .01$) and 4 ($\beta = 1.48\text{e-}04$, $p < .01$) and QML Poisson models 7 ($\beta = 1.36\text{e-}04$, $p < .01$) and 8 ($\beta = 1.26\text{e-}04$, $p < .01$) show that *Uniqueness* is positive and significant. When controlling for endogeneity, Table 3 in models 3 ($\beta = 1.38\text{e-}04$, $p < .01$), 4 ($\beta = 1.45\text{e-}04$, $p < .01$), 7 ($\beta = 1.26\text{e-}04$, $p < .01$) and 8 ($\beta = 1.23\text{e-}04$, $p < .01$) show that *Uniqueness* was also positive and significant. Hypothesis H2 cannot be rejected.[2]

To examine the magnitude of these main effects, the coefficient estimates for the *Coherence* and *Uniqueness* variables in the Arellano–Bond estimation in Table 3 model 8 were used to compute their effect sizes (Cameron & Trivedi, 2005) and are presented in Table 4. To account for differences in the scales of these variables, the unit changes in the *Coherence* and *Uniqueness* variables were examined from the standpoint of an increase of up to a 1 standard deviation from the means of these variables. This involved incrementally increasing each of these variables by 25% (i.e., 0.25, 0.5, 0.75 and 1.0) of their standard deviations. When interpreting the magnitude of their effects, they are interpreted in terms of a % increase in the performance variable of interest with respect to these increases.

In examining their magnitude of effects, Table 4 shows that an increase of 25% in the *Coherence* and *Uniqueness* variables yielded a respective 37.3% and 6.8% increase in a firm's forward patent citations. When examining a 1 standard deviation increase in the *Coherence* and *Uniqueness* variables, a firm's *Coherence* and *Uniqueness*, respectively, increased to 255.2% and 30.3%. As empirical examinations of the effectiveness of different social structures remain extremely limited in AC research (e.g., Enkel et al., 2018; Enkel & Heil, 2014; Kalogerakis et al., 2010), these results show that a firm's coherence has a substantially greater marginal effect on a firm's innovative performance than a firm's unique social structure. This suggests that there is a greater need to examine a firm's coherence over the distant explanations found in AC research (e.g., Enkel et al., 2018; Enkel & Heil, 2014; Kalogerakis et al., 2010).

5 | DISCUSSIONS

This study advances AC research in two ways. First, Cohen and Levinthal (1990) argued that the firm's creative capacity involving the 'behavioral phenomenon of insight' and AC are 'quite similar processes' (p. 130). Yet, since insight is an individual-level phenomenon, AC researchers have not explained the individual level processes that contribute to the development of this insight and how this individual-level insight can be bridged to the firm level AC (see Cohen & Levinthal, 1990; Kim et al., 2016; Song et al., 2018; Todorova & Durisin, 2007; Volberda et al., 2010; Yao & Chang, 2017; Zahra & George, 2002). To address this challenge, a firm level AC concept involving coherence and uniqueness was developed where these social structures are shaped by the individual level RAP. This coherence and uniqueness contribute to AC research by introducing a problem driven process to the firm's assimilation. This problem-driven focus argues that, unlike AC explanations, firms do not assimilate external experiences because it is related to their past experiences or cognitive schemas (Cohen & Levinthal, 1990; Lane & Lubatkin, 1998;

Todorova & Durisin, 2007; Volberda et al., 2010), but because it offers insights into solving a firm's targeted problems. This problem driven focus is important because it generates insights that can overcome a firm's previously established views and thus can overcome the myopic problems found in structural explanations of AC research. Hence, a contribution of this study's concept of coherence and uniqueness is that it is based on a micro-cognitive foundation (RAP) that enables the firm to relate to external experiences in ways that are not constrained by its past experiences/cognitive schemas and thus more fully realizes the innovation potential of the AC concept.

Second, while DC explanations have been used to explain the various dimensions of the AC concept—recognition, assimilation, transformation and exploitation (Ahmed et al., 2019; Song et al., 2018; Todorova & Durisin, 2007; Zahra & George, 2002; Zobel, 2017; Zou et al., 2018)—DC explanations however have not explained how higher order processes can shape these dimensions (Song et al., 2018; Todorova & Durisin, 2007; Zahra & George, 2002; Zobel, 2017; Zou et al., 2018). This study argues that a firm's coherence and uniqueness offer social structures where their exploitation draws on both the firm's assimilation that transformation. Namely, these structures offer an exploitation where the assimilation of external solutions transforms their members' ability to re-examine the assimilated information in a different light. By engaging in this exploitation, coherence and uniqueness offer a higher order learning where the firm develops insight by integrating the AC dimensions of assimilation and transformation. This suggests that unlike DC explanations (Todorova & Durisin, 2007), assimilation and transformation cannot be examined as separate dimensions of the AC concept (see also Zahra & George, 2002; Zobel, 2017). This is because this separation would undermine the development of insight that is needed in developing the firm's higher order learning. As result, coherence and uniqueness contribute to DC explanations of AC research where they offer social structures that not only integrate the assimilation AND transformation dimensions of AC, but this integration offers insights that enable the firm to better adapt to their changing information environments.

This study's concepts of coherence and uniqueness also offer implications for management. First, managers can develop their firm's coherence by promoting a shared understanding of how their technologies can offer analogical solutions to different problems (see also Hargadon & Bechky, 2006; Hargadon & Sutton, 1997). This shared understanding can reveal synergies that offer opportunities to diversify into new lines of related business. Furthermore, firm managers, especially in the biotechnology industry, face increasing pressures to develop new or disruptive innovations. While our uniqueness findings do not examine such influences (see Xie et al., 2018), a firm's uniqueness can offer an assimilation of diverse experiences that can promote the development of such disruptive influences. For instance, studies find firms that develop broad and diverse relationships to supply chain partners can offer new perspectives to the firm's product innovations (Akram et al., 2020; Ferraris et al., 2020; Ng & Sanchez-Aragon, 2021; Xie et al., 2018). This study argues that firm-managers can develop their firm's uniqueness by engaging in these supply chain relationships and that these relationships can offer an important source of disruptive innovation.

5.1 | Limitations and future directions

This study outlines two limitations and future directions. First, this study's findings were limited to the biological advances made during the earlier periods of the biotechnology industry. As there have been many advances made since this study's sampling period (i.e., CRISPR), future research should examine the robustness of this study's findings with a more recent or extended sampling period. Second, there are other properties of coherence that have not been examined by this study. For instance, crisis management has become an increasingly important concern where managers face pressures to innovate to unexpected events (i.e., COVID disruptions on the supply chain), while maintain commitments to their firm's established competencies. Ambidexterity research is useful to addressing this crisis management (Birkinshaw et al., 2016). This is because ambidexterity involves developing the firm's ability to explore new ideas, while exploiting the firm's established competencies. As coherence enables the firm to exploit its firm's past relational associations (i.e., shared understandings) and at the same time allow for the exploration of new relational associations, coherence offers a type of ambidexterity that can deal with a firm's crisis management. Future research is called to examine this ambidexterity property of coherence.

6 | CONCLUSIONS

As knowledge is increasingly recognized as a source of competitive advantage, the challenge facing modern firms is that a firm must continually develop new skills that promote the creation, acquisition and transfer of external knowledge. To develop such skills, this study argues that firms should harness the analogical benefits of its coherent and unique social structures. By appealing to a RAP, this study finds empirical support that coherent and unique social structures offer an assimilation process that can develop insights to a firm's innovative performance. This study outlines the key learning processes (i.e., RAP) and social structures that can promote the development of these insights. This advancement is significant because the underlying learning and social mechanisms responsible for such insights are not well understood in innovation research (Dahl & Moreau, 2002; Gassmann & Zeschky, 2008; Hargadon & Sutton, 1997; Jeong & Kim, 2014). Furthermore, as the learning processes and social structures surrounding the AC concept remain the least understood aspect of AC research (Yao & Chang, 2017), this study also advances AC research. This study argues that the RAP offers an important micro foundation to explaining how a firm's social structures—coherent and unique social structures—can influence a firm's recognition, assimilation and exploitation of external information.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy and or third party restrictions.

ORCID

Desmond Ng https://orcid.org/0000-0003-4558-951X

ENDNOTES

[1] Nevertheless, as *Uniqueness* appears to have a high correlation with the *CumPat* variable, count estimations were conducted where the correlated *CumPat* variable was removed. The estimates on this study's main effect variables—*Coherence* and *Uniqueness*—remained positive and significant at the 1% level.

[2] Additional estimations that include the non-linear effects of *Coherence*, *Coherence*^{2} and *Uniqueness*, *Uniqueness*^{2} were also conducted. These estimations show that the main effects—*Coherence* and *Uniqueness*—remained positive and significant, while their non-linear effects were negative and significant. These findings indicate that *Coherence* and *Uniqueness* may exhibit potential diminishing return effects. Future research is called for to further examine these diminishing effects.

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AUTHOR BIOGRAPHIES

Dr. Desmond Ng is an associate professor of agribusiness and strategy management at Texas A&M University. His research is focused on examining strategic issues at multiple levels of analysis that span intra-firm, firm, inter-firm and market level processes. This involves drawing from varied disciplinary areas that include management, psychology, sociology and evolutionary thinking, including complex system perspectives. He has published in journals such as Strategic Management Journal, Journal of Management Studies, Journal of Small Business Development and Enterprise Development, Journal of Strategy and Management, Emergence, and other related journals.

Dr. Leonardo Sánchez-Aragón is an associate professor at the ESPOL University. His research interests include estimating agricultural productivity, evaluating the effectiveness of agricultural insurance, and the impact of social networks. He has served ESPOL as the Associate Dean and as the Dean of the Faculty of Social and Humanistic Sciences. Currently, he is an associated researcher of Center of Rural Research at ESPOL.

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