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Strategic resource decay

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Abstract

Research Summary: The isolating mechanisms of strategic resources ensure their robustness against external factors. However, resources are also internally dynamic: Natural resources are depleted, employees retire, and patents expire. We develop a theoretical framework about the limitations to the sustainability of resource-driven competitive advantage and posit that most strategic resources endogenously lose their value-creating potential due to two factors, time and deployment, through what we label "strategic resource decay." Our typology links resource characteristics to the mechanisms of decay and replenishment. We then examine the relationship between strategic resource decay and firm performance and explore its boundary conditions. We conclude that the firm can mitigate the negative effects of decay if it synchronizes its resource management actions with the temporal properties of its strategic resources.

Managerial Summary: To sustain a competitive advantage, managers need to understand not only the competitive dynamics of the industry but also the lifespans of the firm's strategic resources. Decay limits the useful lives of strategic resources temporally and/or in the resources' potential extent of deployment. Because firms can potentially prevent the exhaustion of their non-tradable strategic resources through replenishment, the decay of tradable strategic resources poses a greater challenge for managers. We also posit that strategic resource decay is a more salient threat in industries that are not characterized by rapid change.

To counter the threat posed by strategic resource decay, firms need to engage in resource management activity, the timing and extent of which should be aligned with the temporal properties of the strategic resources.

KEYWORDS

asset erosion, competitive advantage, resource decay, resource depletion, sustainable rents

"You may delay, but time will not."—Benjamin Franklin

1 | INTRODUCTION

In 2005, the Cannington Mine in Australia produced a record 1,250 metric tons of silver. Michael Jordan scored 29,277 points for the Chicago Bulls, carrying his team to six NBA championship titles over the course of 13 seasons. The cholesterol lowering drug Lipitor was first launched in 1997. Until the expiration of the related patent in 2011, Lipitor generated over $100 billion in sales for Pfizer, making this patent the most profitable ever granted. These examples illustrate the building blocks of sustainable competitive advantage according to the resource-based logic: valuable and scarce resources with isolating mechanisms that safeguard them from like-minded competitors (Mahoney & Pandian, 1992).

However, these firms could not sustain their competitive advantages because these strategic resources lost their value-creating potentials, independent of competitive forces. The Cannington Mine now provides only a quarter of its peak output, and, like all primary silver deposits, it is expected to be depleted in the foreseeable future (Sverdrup, Koca, & Ragnarsdottir, 2014). The Chicago Bulls have not won a championship title since Michael Jordan's second retirement in 1998. After the Lipitor patent expired, Pfizer's profits decreased by almost 20% (Thomas, 2012).

In the resource-based view (RBV), changes in the value-creating potentials of strategic resources are critical for understanding the sustainability of competitive advantage (Adner & Zemsky, 2006). Consequently, most literature that defines strategic resources addresses how isolating mechanisms protect the value of these resources from external factors (e.g., competition and technological changes). Yet, the literature says little about how strategic resources degrade—that is, lose their value-creating potential—endogenously, even though it is rife with examples of such phenomena: Natural resources are depleted (e.g., Hart, 1995), employees retire (e.g., Tzabbar & Kehoe, 2014), patents expire (e.g., Markman, Espina, & Phan, 2004), and knowledge is forgotten (e.g., Epple, Argote, & Devadas, 1991). We begin by reviewing the RBV literature, where we find no prior attempt to develop a theoretical framework that explains how strategic resources degrade endogenously and identifies the characteristics that determine their lifespans.

To address this gap, we introduce the concept of strategic resource decay (SRD), which denotes the endogenous degradation of strategic resources. We also develop a two-dimensional typology of strategic resources that explains: (a) how strategic resources decay and (b) whether their exhaustion is preventable through replenishment—that is, the process of reinvesting in resources to extend their useful lives. To capture the resource characteristics that correspond

with the mechanisms of SRD, we extend the work of Thirlby (1943) by classifying strategic resources as perishable, depletable, or both. Perishable resources decay over time, whereas depletable resources decay when they are deployed. In regard to the second dimension of our typology, we posit that firms can potentially prevent the exhaustion of non-tradable strategic resources through replenishment. However, firms cannot extend the useful lives of tradable strategic resources at the resource level. Faced with the threat of decay-driven exhaustion of tradable strategic resources, firms might be able to replace these resources, reconfigure or redeploy their existing capabilities, or create new capabilities. Next, we examine how SRD can affect subsequent firm performance through resource exhaustion, and we explore the role the exogenous degradation plays in this relationship. We then extend our framework with propositions for managing SRD. We argue that the actions prescribed for countering environmental dynamism (e.g., Helfat & Peteraf, 2003; Sirmon, Hitt, & Ireland, 2007) also moderate the negative SRD–performance relationship when they are synchronized with the temporal properties of strategic resources—namely, decay rate, variability of the decay rate, and remaining lifespan. Finally, we discuss the implications of SRD for future research and practice.

2 | THEORETICAL BACKGROUND

In the RBV, resource heterogeneity explains the variance in performance among firms, while inimitability, nonsubstitutability, and immobility of resources preserve this variance (Peteraf, 1993). The firm achieves competitive advantage by creating more economic value than its competitors do, which then drives superior performance (Crook, Ketchen, Combs, & Todd, 2008). Economic value is defined as the difference between the benefits gained by the purchasers of a product or service and its cost to the firm (Peteraf & Barney, 2003; Postrel, 2018). Firms can achieve and sustain competitive advantage if they possess strategic resources, which are typically scarce, valuable, and inimitable (Barney, 1991).

Scarcity might stem from rarity or uniqueness (Barney, 1991; Mahoney & Qian, 2013), however, a resource is deemed scarce if demand for it exceeds its supply (Peteraf, 1993). Because resource value and scarcity are determined exogenously (Priem & Butler, 2001; Srivastava, Fahey, & Christensen, 2001), the RBV literature regards competition and other external factors and the resulting exogenous changes as the main threats to the value-creating potential of strategic resources. In turn, the existing literature focuses on how the isolating mechanisms associated with strategic resources, which are barriers to imitation, mobility, and substitution (Rumelt, 1984), ensure that strategic resources remain robust against competitive forces. It thus says little about the possibility that strategic resources might degrade endogenously and the ensuing threat that such degradation poses to the firm's competitive advantage and performance.

As noted above, we first reviewed the research on strategic resources.[1] Of the 819 published theoretical and empirical articles that matched our search criteria, 59 discussed resource degradation. We classified the drivers of degradation and found that 36 of these articles discussed external factors, such as imitation (e.g., Srivastava et al., 2001), technological changes

[1]We conducted a search (in Google Scholar and Web of Science) based on the articles published in *Academy of Management Journal*, *Academy of Management Review*, *Administrative Science Quarterly*, *Journal of Management*, *Journal of Management Studies*, *Management Science*, *Organization Science*, *Strategic Management Journal*, *Strategic Organization*, and *Strategy Science*. In our review, we included all articles that contained at least one of the following terms: "decay*," "degrad*," "erosion," "erode*," "depreciat*," "deteriorat*," "deplet*," along with "resource-based view."

(e.g., Amit & Schoemaker, 1993; Markides & Williamson, 1996; Pacheco-de-Almeida, 2010), and changes in the consumer base (e.g., Adner & Zemsky, 2006; Markides & Williamson, 1994). Internal factors, including forgetting (e.g., Epple et al., 1991; Henderson & Cool, 2003), value appropriation (e.g., Breton-Miller & Miller, 2015; Foss & Foss, 2005), and turnover (e.g., Oliver, 1997; Winter & Szulanski, 2001), were examined in 16 articles. Nine articles discussed both external and internal factors, and 16 did not describe the drivers of degradation. With a few exceptions, such as patents and hydrocarbon reserves (Breton-Miller & Miller, 2015; Stadler, Helfat, & Verona, 2013), the majority of the strategic resources that were linked to internal factors of degradation were non-tradable, such as firm-specific human capital (e.g., Dess & Shaw, 2001; Kamoche, 1996), know-how and knowledge (e.g., Eggers, 2012; Parmigiani & Holloway, 2011), and reputation (e.g., Cabral, 2015; Kim, Kim, & Qian, 2018). None of the articles provided a theoretical framework that distinguished between exogenous and endogenous degradation of strategic resources and specified the mechanisms of endogenous degradation. Thus, the performance implications of endogenous degradation remain unaddressed. We attribute this gap to the literature's emphasis on exogenous changes in defining threats to resource-driven competitive advantage and to an implicit assumption that firms can indefinitely replenish their non-tradable strategic resources.

Exogenous changes typically involve more discontinuity and uncertainty than endogenous ones do. Jolts—defined as sudden and unprecedented exogenous changes—can even shape entire industries (Meyer, Brooks, & Goes, 1990). The existing research primarily emphasizes how exogenous changes threaten resource-driven competitive advantage.

> Any industry or market segment will undergo Schumpeterian shocks such that most equilibria (if computable at all) will have finite lives. Robust strategies thus must pay attention to disequilibrium, uncertain futures and ambiguous relationships. Without ambiguity and complexity, the SA [strategic asset] question would perhaps be reducible to a rational end-game analysis. (Amit & Schoemaker, 1993, p. 43)

This emphasis on exogenous changes that affect strategic resources downplays the impact of endogenous changes, which, though more predictable and continuous, can nevertheless threaten firms' competitive advantage and performance. Regardless of the predictability of the changes it faces, a firm is likely to be constrained in its ability to substitute negatively affected strategic resources due to the very isolating mechanisms that protect these resources from competition (Breton-Miller & Miller, 2015). The stream of research that examines non-tradable strategic resources acknowledges that such resources can lose value over time (e.g., Knott, Bryce, & Posen, 2003). At the same time, it implicitly assumes that the useful lives of non-tradable strategic resources can be extended indefinitely and deems resources' robustness to competition as sufficient to maintain resource heterogeneity: "nontradability is required to ensure that the asset, once deployed in a given product market, remains in fixed supply" (Dierickx & Cool, 1989, p. 1509).

3 | STRATEGIC RESOURCE DECAY

The literature uses a variety of terms interchangeably to address exogenous and endogenous degradation of resources. We refer to the degradation of strategic resources driven by external factors as *strategic resource erosion*. We refer to the endogenous degradation of strategic resources as *strategic resource decay* (SRD). In developing our framework of SRD, we first build

a typology that defines strategic resources along two dimensions: (a) depletability/perishability, which explains how a strategic resource decays, and (b) tradability, which explains whether the firm can potentially prevent the resource's exhaustion through replenishment. In this section, we introduce our typology of strategic resources.

3.1 | Perishability and depletability

We build on Thirlby's (1943)[2] work in defining the resource characteristics that correspond with the mechanisms of endogenous degradation. Thirlby (1943) posits that resources may contain two types of value-creating potential: (a) value-creating potential that the firm can deploy in full at any time and (b) value-creating potential that is temporally dispersed, available only in limited amounts during each period of the resource's lifespan. Based on these definitions, we label strategic resources that contain value-creating potential consistent with the first type as *depletable strategic resources*, which degrade as a function of the firm's deployment activity. We label strategic resources that contain value-creating potential consistent with the latter type as *perishable strategic resources*[3]; these resources degrade as a function of time.

In our framework, decay represents the decrease in a resource's total value-creating potential, holding external factors constant. Here, resources are bundles of value-creating potential.[4] Depletable strategic resources decay and their subsequent value-creating potential decreases upon their deployment by the firm. For example, the owner of a silver mine can extract ore at different times as long as the mine contains ore. Holding constant external factors, such as market prices and technological advancements in the recycling of metals, the ore deposit retains its value-creating potential at the firm's discretion.

Perishable strategic resources, in contrast, are time-sensitive, meaning that the firm can utilize only a portion of their value-creating potential in a given period and their value-creating potential cannot be preserved. However, the firm's deployment of a perishable resource in one period does not affect its subsequent value-creating potential. For example, a patent provides value-creating potential throughout its lifespan. The protection provided by a patent cannot be deferred, and the firm incurs opportunity costs if it does not deploy the patent in a given period.

There are two exceptions to this classification.[5] First, some strategic resources decay due to both time and deployment; thus, they are perishable and depletable at the same time. Second, some strategic resources are perpetual, continuously providing a value-creating potential. Next, we explain how depletable and perishable strategic resources decay.

An ore deposit is a depletable resource. Let us assume that a mining firm acquires an ore deposit containing an estimated reserve of 100 tons (O_{t0}) of superior grade ore. The change in the reserve between any two years, dO/dt, indicates the annual rate of deployment of the deposit in tons (M). The firm extracts 10 tons of ore every year (10% of the initial reserve O_{t0}),

[2]In his article, "Permanent Resources," George F. Thirlby (1943) responds to Hayek's (1941) *The Pure Theory of Capital* and suggests a new classification of resources based on a concept he labels "cumulability" in an effort to delineate the concept of permanence for resources.

[3]Our definitions of depletable and perishable resources are consistent with Thirlby's (1943) definition of resources with "cumulable" and "non-cumulable" value-creating potential, respectively.

[4]Penrose (1959, p. 60) defines a resource as "a bundle of possible services."

[5]We thank an anonymous reviewer for bringing up another, albeit rare, category of strategic resources that self-replenish, increase over time, and decay upon deployment (e.g., a herd of livestock, a stock of fish, and nuclear fuel in a breeder reactor).

and the annual decay rate (r) of the deposit equals 10%, calculated as $r = M/O_{t0}$. For the sake of simplicity, we also hold constant the related average costs at \$100,000 per ton (C) and assume that the market price reflects customer willingness to pay—that is, perceived benefits gained by the purchasers of the good (Peteraf & Barney, 2003). Based on a market price (P) of \$600,000 per ton for the ore, the reserve has a total value-creating potential of \$50 million at t_0 ($V_{t0} = (P - C)\, O_{t0}$). Therefore, holding external factors constant, the deposit decays by \$5 million annually during any year t:

$$D_t = V_{t-1} \frac{M}{O_{t-1}} \tag{1}$$

Patents are typically perishable resources. Suppose a patent for an innovative drug with curative properties is issued for 20 years. At t_0, the remaining useful life of the patent is 20 years (L_{t0}); at the end of t_1, the patent has a remaining useful life of 19 years (L_{t1}); and so on. Therefore, the decay rate of the patent equals 5% ($r = 1/L_{t0}$). Each year, the patent loses 5% of its initial value-creating potential (V_{t0}) or $1/L_{t-1}$ of its remaining value-creating potential (V_{t-1}), regardless of whether the firm deploys it. The firm initially estimates that the drug will generate \$60 million in annual sales (S). Assuming that the price reflects customer willingness to pay and holding constant the related annual total costs (C) incurred by the firm at \$10 million, the patent has a total value-creating potential of \$1 billion at t_0, calculated as $V_{t0} = (S - C)\, L_{t0}$. Holding external factors constant, the patent decays by \$50 million at any year t:

$$D_t = \frac{V_{t-1}}{L_{t-1}} \tag{2}$$

The remaining value-creating potential of the patent at the end of any year equals:

$$V_t = V_{t0} - \sum_{t=1}^{t} D_t \tag{3}$$

Time affects a variety of resources: People embodying human capital retire; contracts, licenses, and patents expire; and knowledge and reputation are forgotten. To create value, resources must be deployed: Minerals must be extracted, athletes must perform, and contract options must be exercised. Therefore, most strategic resources lose value endogenously due to decay. Firms that understand how decay occurs (i.e., due to time and/or deployment) can align the extent and timing of their actions with the patterns of decay, as explained in the section on the temporal properties of strategic resources later in this article.

3.2 | Tradability

Tradability of a strategic resource refers to the extent that its value-creating potential is transferrable across firms.[6] Non-tradable strategic resources either cannot be acquired in factor markets or do not retain their value-creating potential when traded (Peteraf, 1993). For some strategic

[6]Teece, Pisano, and Shuen (1997, p. 518) suggest that firm capabilities cannot be traded "short of buying the firm itself, or one or more of its subunits." Consistently, our definition of tradability excludes merger and acquisition activities.

resources, such as reputation and customer loyalty, there is no factor market (Dierickx & Cool, 1989). Other non-tradable strategic resources might be—technically—"tradeable but more valuable within the firm that currently employs them than they would be in other employ" (Peteraf, 1993, p. 183). Tradability of this type of non-tradable strategic resources is limited due to their firm-specific attributes, which make the resources specialized to the firm's capabilities[7] and other resources at varying levels. Non-tradable strategic resources are synergistic; the inimitability and scarcity of a non-tradable strategic resource are supported by its complementarity with the firm's capabilities and other resources as well as the processes through which it is built (Pacheco-de-Almeida & Zemsky, 2007). Since capabilities themselves degrade and require constant maintenance (Helfat & Peteraf, 2003; Rahmandad & Repenning, 2016), non-tradable strategic resources cannot be perpetual.

In contrast, tradable strategic resources are inherently scarce and have high "stand-alone" value-creating potential, which is available to any firm that can access them (Schmidt & Keil, 2013, p. 211). They retain this potential when traded (Barney, 1991; Mahoney & Pandian, 1992). Such resources are inimitable when their scarcity is protected by isolating mechanisms, such as property rights. They are typically acquired in strategic factor markets, where firms compete for scarce resources with superior value-creating potential (Barney, 1986). Absent luck, the firm can acquire a tradable strategic resource without paying a price that reflects its "full value" if it can assess the resource's value better than its competitors do (Barney, 1986; Makadok & Barney, 2001). Firms can also develop tradable strategic resources, such as patents (Ahuja & Katila, 2001), that they can trade in factor markets (Chatain, 2014). Scarce human capital, patents for innovative technologies, and rare natural resources are examples of tradable strategic resources.

In regard to SRD, the tradability of a strategic resource explains whether the firm can potentially prevent the decay-driven exhaustion of the resource through replenishment. Exhaustion occurs when a perishable or a depletable resource has no remaining value-creating potential (e.g., an expired patent, an exhausted mine, and a retired employee). Replenishment refers to the process of extending the useful life of a strategic resource through reinvestment, without engaging in activities that involve reconfiguring or redeploying firm capabilities (discussed later in the section on resource management). Except for perpetual strategic resources, both tradable and non-tradable strategic resources are subject to the same forces of decay (i.e., time and/or deployment), which can result in the exhaustion of both of these types of strategic resources.

However, tradable and non-tradable strategic resources differ in their structures, which in turn determines whether they can be replenished. Firms internally build non-tradable strategic resources by accumulating and integrating the necessary components (Dierickx & Cool, 1989). By definition, these components are not inherently scarce and do not constitute strategic resources on their own. For instance, a reputation for quality requires a group of satisfied customers who agree on certain attributes of the products or services delivered by the firm (Mishina, Block, & Mannor, 2012). This can be achieved only through the utilization of the firm's own capabilities over time (Rindova, Petkova, & Kotha, 2007). However, firms also "buy to build" (Maritan & Peteraf, 2010, p. 1385); that is, some non-tradable strategic resources are built from generic assets that are acquired in factor markets (Denrell, Fang, & Winter, 2003). For example, some production plants and infrastructure are internally built by firms using inputs available on the market (Pacheco-de-Almeida, Henderson, & Cool, 2008). Often, non-

[7]Capabilities (also known as organizational capabilities) represent the firm's ability "to perform a coordinated set of tasks" (Helfat & Peteraf, 2003, p. 999) using firm resources and routines. Routines are repetitive sets of activities learned over time that are essential to the firm's capabilities (Dosi, Nelson, & Winter, 2000).

tradable strategic resources involve a combination of both acquired and internally generated components: "'Generic labor' is rented in the market; firm-specific skills, knowledge and values are accumulated through on-the-job learning and training" (Dierickx & Cool, 1989, p. 1505).

The composite structure of non-tradable strategic resources implies that they decay as their components become exhausted. For example, the firm-specific human and social capital embodied by the employees of a firm can decay as a result of the retirement of individual employees. In this case, each retirement that causes the decay of the strategic resource entails the exhaustion of a component. However, as long as the firm retains a critical mass of such resources (Dierickx & Cool, 1989) and the related capabilities (e.g., hiring and training) remain functional, new employees can be hired and can accumulate firm-specific human and social capital over time by working alongside the long-term employees, thereby replenishing the non-tradable strategic resource. Likewise, a firm-specific infrastructure might decay over time as its physical components reach the ends of their useful lives. However, this strategic resource, too, can be replenished through the replacement and integration of fungible components. Accordingly, a firm can potentially replenish a non-tradable strategic resource through two processes or a combination of both: (a) replenishment based on internally generated fungible components or (b) replenishment based on the acquisition of generic assets that are subsequently integrated into the related capabilities. One important caveat is that replenishment of non-tradable strategic resources is not guaranteed. Potential challenges associated with this process are discussed in the section on the relationship between SRD and firm performance.

In contrast, the value-creating potentials of tradable strategic resources are not necessarily contingent on other resources and capabilities, meaning that a tradable strategic resource, on its own, can potentially be the source of competitive advantage. For the same reason, the value-creating potentials of tradable strategic resources are not supported by a multitude of components, and these resources tend to decay and become exhausted as a whole. Accordingly, the finite lifespans of tradable strategic resources often determine when or after how much deployment they will become exhausted. For example, a sports team may achieve success due to the individual skills and effort of a star athlete. Following the retirement of that star athlete, however, the team would need to find a replacement to compensate for the lost scarce human capital.

In sum, a tradable strategic resource resembles a monolithic building that is acquired. A non-tradable strategic resource resembles a building of masonry construction that is built brick by brick as the firm accumulates and integrates components coherently and that can potentially be repaired through the replacement of the deteriorating "bricks."

3.3 | A typology of strategic resources

Table 1 illustrates our typology of strategic resources based on depletability/perishability and tradability. In this section, we provide examples of the types of strategic resources in each cell.

3.3.1 | Cell I

Depletable and tradable strategic resources fall under this category. A silver deposit is a scarce resource that is depleted as a function of the firm's extraction activity, and the firm cannot replenish it. Some of the resources in this cell are intangible, such as contracts (Hall, 1992) that are issued for the performance of tasks or delivery of products of a certain quantity.

TABLE 1 Strategic resource characteristics and the corresponding patterns of decay

Strategic resource characteristics	Depletable	Depletable and perishable	Perishable	Perpetual
Tradable	I The resource decays upon deployment and its exhaustion is not preventable through replenishment.	II The resource decays both upon deployment and over time and its exhaustion is not preventable through replenishment.	III The resource decays over time and its exhaustion is not preventable through replenishment.	IV The resource does not decay.
Non-tradable	V The resource decays upon deployment and its exhaustion is preventable through replenishment.	VI The resource decays both upon deployment and over time and its exhaustion is preventable through replenishment.	VII The resource decays over time and its exhaustion is preventable through replenishment.	

For example, in 2001, Arista Records signed a $100 million contract with Whitney Houston for a series of six albums (Saraceno, 2001). For the record label, the release of each album diminished the subsequent value-creating potential of the contract, which granted the firm the exclusive right to publish the artist's work. Intellectual properties that are tradable and valuable when they are novel, such as a movie script, can also be depleted upon being deployed.

3.3.2 | Cell II

These strategic resources are perishable, depletable, and tradable. Human resources have limited lifespans. The firm can also experience diminishing returns from them due to a lack of motivation and value appropriation following their past deployment. For example, Miller and Shamsie (2001) found that after an initial surge of performance, skilled managers became more risk-averse over their careers and lost their value-creating potential. Such scarce resources are acquired in the market, and the firm cannot replenish them. A uranium deposit is another depletable scarce resource that decays over time due to the atomic structure of the element. Oil and gas leases are also often both perishable and depletable; such leases allow operators to access or explore for oil and gas deposits for a specified period of time, so they decay over time. At the same time, every oil and gas deposit contains a finite amount of hydrocarbons and is depleted upon deployment.

3.3.3 | Cell III

Tradable and perishable strategic resources, such as patents, duration-based employment contracts with individuals who embody scarce human capital, and licenses granting exclusive rights to a firm to operate in certain areas or engage in an activity for a given duration (e.g., broadcasting

rights), fall within this cell. Such resources decay over time regardless of the firm's deployment activity, and the firm cannot prevent their exhaustion through replenishment.

3.3.4 | Cell IV

Perpetual strategic resources are tradable, and their value-creating potential is dispersed over time. However, unlike perishable resources, perpetual resources do not expire. Ownership or perpetual usage rights for scarce properties (e.g., a store on Fifth Avenue in New York City) are perpetual strategic resources. Likewise, some franchise agreements are perpetual strategic resources. For example, some bottling companies have perpetual rights to produce and market products of the Coca-Cola Company. Similarly, Starbucks sold Nestlé the perpetual rights to sell ready-to-drink Starbucks branded coffee and tea products outside Starbucks' own stores (Nestlé, 2018).

3.3.5 | Cell V

Non-tradable and depletable strategic resources decay upon deployment, but their exhaustion can be prevented through replenishment. For example, firms often design and build custom production lines and facilities by accumulating and integrating the necessary components (Pacheco-de-Almeida et al., 2008). Such resources can decay due to the wear and tear of their components, such as machinery, robotics, and conveyor belts, as they are utilized. Likewise, equipment used in space travel, such as launch systems, is largely not recoverable or reusable upon deployment, so it is depletable. Launch systems are custom designed and built for specific projects and missions, making them useful only to the space agencies or companies that are involved in these missions and projects. A design or prototype for the updated version of an existing product also falls under this category because it loses its newness upon being deployed. Unlike unpublished intellectual property (in Cell I), its value-creating potential is attached to the firm and the existing product line. Inventories of specialized and non-perishable production inputs or semi-finished goods (e.g., mechanical or electronic components that can be used to manufacture a specific product) are non-tradable and depletable as well. Such resources do not hold their value outside the firm and are depleted during the production of the final goods. However, the depletable components of these strategic resources are not scarce on their own, and the firm either generates them internally or acquires them in the market. By replacing these fungible components, the firm can potentially replenish a decaying resource of this kind and prevent its exhaustion.

3.3.6 | Cell VI

The decay of strategic resources that are non-tradable, perishable, and depletable is driven by both time and deployment, but these resources can potentially be replenished. Vertically integrated oil and gas firms build gathering lines to transport crude oil and raw natural gas between their wells and processing facilities. Such pipelines are made of generic components, but they are non-tradable because they are co-located with and customized for the firm's other resources. A natural gas pipeline can decay both due to aging and corrosion under atmospheric conditions

and due to intense mechanical stress resulting from its usage (Kiefner & Rosenfeld, 2012). However, the firm can replenish the pipeline by acquiring and installing generic components.

Some production inventories and intermediate goods are also non-tradable and perishable. For example, most premium liquors and wines are produced through highly firm-specific processes (e.g., barrel aging) and may contain firm-specific ingredients (e.g., if estate bottled). Such products often have protected denominations of origin and command a price premium if they are bottled and sold under the producers' brand. A semi-finished product stock of this kind is perishable, and it is depleted as the firm bottles and sells it as the final product. At the same time, the firm can prevent the exhaustion of such inventories by ensuring a steady flow of production.

This logic of simultaneous perishability and depletability can apply to human capital as well. Human resources typically decay as a function of time. However, some human resources are also limited in how much the firm can deploy them in a given period or function. These limitations might stem from the characteristics of those resources, such as the level of motivation or physical condition of employees, or the rules and regulations governing an industry or a profession.

For example, the staff of a nuclear power plant embodies highly firm- and site-specific human capital because operating procedures of a nuclear power plant and the training required for employees depend on factors such as the lifecycle and particular characteristics of the facility as well as the technologies utilized by the operator (International Atomic Energy Agency, 2009). Regardless of the past experience and education of the new employee, the operator needs to provide extensive training, because this type of human capital cannot be acquired in the market. At the same time, the U. S. Nuclear Regulatory Commission (2020) does not permit "radiation workers" to be exposed to more than 1 rem (a unit of radiation dose equivalent) of radiation times the employee's age cumulatively throughout the employee's career. Therefore, the non-tradable human capital embodied by the staff of a nuclear power plant decays due to both time (i.e., aging toward retirement) and deployment.

Traditionally, the "Big Four" accounting firms hire fresh graduates for junior audit roles and endow them with firm-specific human and social capital over time. However, one of the main reasons these firms typically experience a high turnover of junior audit staff is the firms' "up-or-out" promotion practices. Typically, these junior specialists are either quickly promoted or leave the firm if they cannot find a promotion opportunity (Gertsson, Sylvander, Broberg, & Friberg, 2017). Therefore, whether they perform satisfactorily or not, each completed audit assignment limits the future deployability of junior audit staff in their current roles; successful junior auditors are promoted within the firm, while the underperformers are expected to leave. Nevertheless, the firm can potentially replenish its non-tradable human capital if it manages to hire new employees on time and integrate them successfully into its capabilities.

3.3.7 | Cell VII

Resources that fall within this cell are also non-tradable and replenishable. However, unlike the resources in Cells V and VI, these resources decay exclusively over time, at regularly occurring intervals. Non-tradable and perishable resources, such as firm-specific knowledge, human capital, and social capital, often decay as the people embodying them forget or age and retire. Some firm-specific facilities and infrastructures also decay temporally regardless of their usage. For example, a telecommunication network decays because cable materials cannot retain their

integrity forever. However, the data transmitted through a cable (i.e., the extent of its deployment) do not contribute to its decay.

4 | PROPOSITIONS

4.1 | SRD and firm performance

In this section, we discuss how SRD threatens firm performance. In the RBV, strategic resources enable competitive advantage, which leads to superior performance (Barney, 1991; Crook, Ketchen, Combs, & Todd, 2008; Peteraf, 1993).[8] As an antecedent of resource exhaustion, SRD can negatively affect firm performance by: (a) decreasing the effectiveness or efficiency of firm capabilities, directly affecting the firm's value chain, or (b) eliminating the isolating mechanisms of strategic resources, rendering the firm vulnerable to competition.

The most proximal performance-related consequence of SRD is its detrimental effect on capabilities. Strategic resources are integrated into capabilities (Amit & Schoemaker, 1993), which are how the firm utilizes its existing resources and "make[s] a living" (Winter, 2003, p. 991). Once a strategic resource decays and is exhausted, the firm's related capabilities can be affected, leading to higher costs, lower productivity, or a breakdown of those capabilities. For example, a key scientist's retirement could weaken her former firm's research and development capability (Tzabbar & Kehoe, 2014). In turn, firm-level performance, which is determined by the effectiveness and efficiency of the combination of firm capabilities, would suffer (Ray, Barney, & Muhanna, 2004).

In addition, SRD can have indirect effects on firm performance through other resources that are complementary to the decaying strategic resource. Firms often bundle and deploy strategic resources with routines and other strategic as well as non-strategic resources (Adner & Helfat, 2003), such as supply chain resources (Ellram, Tate, & Feitzinger, 2013). The values of these complementary resources and routines might depend on the decaying strategic resource. Alternatively, they might be co-specialized with the decaying resource, resulting in a bilateral dependence (Teece, 1986). Thus, the complementarity within a resource bundle might make resources and routines context-dependent (Breton-Miller & Miller, 2015). In such a case, once the decaying strategic resource is exhausted, these other resources and routines might turn into sunk costs and further decrease firm performance.

SRD can also hurt firm performance without directly hindering the firm's capabilities. The isolating mechanisms of strategic resources enable the firm to sustain a competitive advantage by protecting it from competition (Peteraf, 1993). For example, patents deter imitation (Markman et al., 2004). However, as a patent decays and expires, the firm's competitive advantage becomes vulnerable, because competitors are likely to saturate the market with imitative products. This was the case for Lipitor: Pfizer's competitors rushed to release generic versions of the drug when its patent expired. On the flip side, the scarcity and the isolating mechanisms of strategic resources that protect the firm against imitation and substitution might also prevent the firm from substituting or replenishing an exhausted strategic resource (Breton-Miller & Miller, 2015; Peteraf, 1993). Accordingly, the inherent scarcity of a tradable strategic resource

[8]If stakeholders appropriate the value resulting from a competitive advantage, the firm might fail to achieve superior performance. We exclude the problem of value appropriation from our model. For a detailed discussion of this issue, see Coff (1999).

can make it harder for the firm to find a viable substitute in factor markets. Thus, SRD can have enduring effects on firm performance.

Non-tradable strategic resources are not immune to decay-driven exhaustion. For these resources, isolating mechanisms can impede both imitation and replenishment. Time compression diseconomies impede imitation when it is more costly to accumulate a resource quickly, and asset mass efficiencies imply higher costs for potential imitators that lack an initial critical mass (Dierickx & Cool, 1989). However, these mechanisms can prevent the firm from replenishing a non-tradable strategic resource if it does not act in a timely manner. For example, one reason Jack Cooper, a car hauling contractor for major automakers, filed for bankruptcy was the high maintenance costs of its aging fleet (Corrigan, 2019). Causal ambiguity, which often surrounds non-tradable strategic resources (Dierickx & Cool, 1989), limits competitors' understanding of the relationship between the firm's capabilities and their outcomes (King, 2007). However, it might also limit the firm's ability to prevent the exhaustion of its own non-tradable strategic resources. Without a full understanding of the causal links in its value chain, the firm cannot replenish a decaying resource.

Employees embody non-tradable strategic resources such as firm-specific knowledge and social capital (e.g., Coff, 2002; Hitt, Bierman, Uhlenbruck, & Shimizu, 2006) that they might have accumulated over long periods of time. Further, accumulation of these resources might require hands-on experience and close contact with stakeholders, which cannot always be compensated for or accelerated by the firm's routines or capabilities, such as employee onboarding and training. Thus, replenishment of non-tradable strategic resources cannot be guaranteed if the decay is caused by the turnover of employees who have been endowed with large amounts of firm-specific resources over extended periods of time. For example, firm-specific human and social capital embodied by a cadre of homegrown executives cannot easily be replenished by hiring new employees. Further, human resources can become socially complex, such that their combined output is greater than the sum of their individual inputs (Alchian & Demsetz, 1972; Coff, 1999). While it might act as an isolating mechanism (Barney, 1991), social complexity can also limit the firm's ability to replenish a non-tradable strategic resource. For example, an individual's retirement can decrease the value-creating potential of the remaining employees (Chi, 1994).

> **Proposition 1.** *All else constant, SRD is negatively related to subsequent firm performance.*

Regarding the performance implications of SRD, the fundamental difference between tradable and non-tradable strategic resources is that the firm can potentially prevent the exhaustion of non-tradable strategic resources by replenishing them due to their composite structure; that is, the firm can replace the exhausted components, thereby extending the lifespan of a non-tradable strategic resource. Conversely, the firm cannot replenish tradable strategic resources which are inherently scarce, valuable, and "monolithic." Strategic resources enable the firm to implement unique strategies (Barney, 1986), and their exhaustion can translate into a disruption of the fit among firm resources, strategy, and the external environment, which drives value creation (Black & Boal, 1994). Thus, unless the firm can find substitutes or manages to reconfigure its capabilities, tradable strategic resources can support only temporary competitive advantages. Because they are scarce, finding viable substitutes for them can prove challenging. Further, the firm must compete for them in factor markets, where competitors that know about the firm's previous competitive advantage can bid away the value-creating potential of a substitute in an effort to imitate the firm's strategy. Thus, compared with the replenishment of

a non-tradable strategic resource, managing the decay of a tradable strategic resource involves greater uncertainty, particularly because factor market competition may intensify.

Proposition 2. *The negative relationship between SRD and subsequent firm performance is stronger for tradable strategic resources than it is for non-tradable strategic resources.*

4.2 | Strategic resource decay and erosion

We have described the relationship between SRD and firm performance in isolation, holding constant external factors such as competition that erode strategic resources. However, strategic resources are often simultaneously subject to both the exogenous erosion and the endogenous decay, which might interact with one another in driving exhaustion. Erosion of a strategic resource decreases its overall remaining value-creating potential and reduces the extent to which it will subsequently decay. Returning to the example of the ore deposit used in Equation (1), suppose that at t_2, an oversupply of the ore by competitors decreases its unit price by 20%, which represents the rate of erosion (q). The value-creating potential lost due to erosion at $t_2(E_{t2})$ equals \$9 million:

$$E_t = V_{t\text{-}1}\ q_t \tag{4}$$

Correspondingly, decay's impact at t_2 decreases to \$4 million due to erosion, although the rate of deployment of the resource (M) does not change:

$$D_{t2} = (V_{t1} - E_{t2})\frac{M}{O_{t1}} \tag{5}$$

In the example of the pharmaceutical patent used in Equations (2) and (3), a value-creating potential of \$850 million remains at the end of t_3. Let us assume that another firm launches a product with prophylactic properties against the disease, which shrinks the market for the curative drug by 40% during t_4. This change represents the rate of erosion at t_4 (q_{t4}). As a result, the patent erodes by \$340 million at t_4:

$$E_{t4} = V_{t3} q_{t4} \tag{6}$$

The value-creating potential lost due to decay correspondingly decreases to \$30 million:

$$D_{t4} = \frac{(V_{t3} - E_{t4})}{L_{t3}} \tag{7}$$

Subsequently, by the end of t_4, the remaining value-creating potential of the patent equals \$480 million, per the following equation:

$$V_t = V_0 - \sum_{t=1}^{t} (D_t + E_t) \tag{8}$$

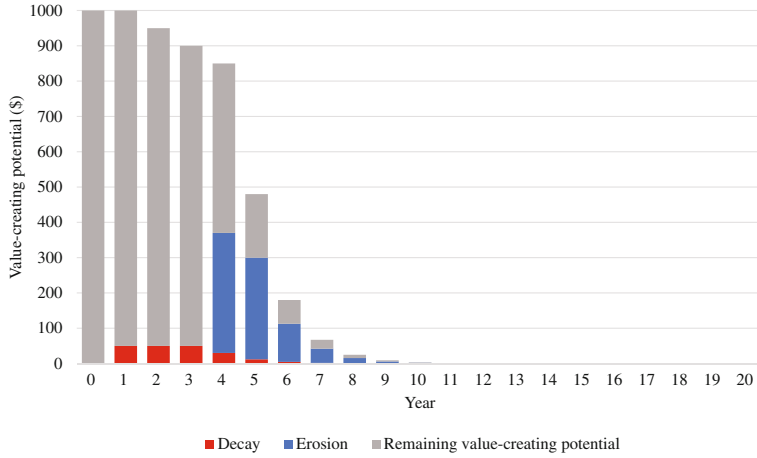

FIGURE 1 Simultaneous decay and erosion of a patent

Let us further assume that from t_5 onward, erosion accelerates due to market changes such as availability of the prophylactic medicine and increasing public awareness, and the rate at which the patent erodes exponentially reaches 60%. In this scenario, the patent is practically worthless by t_{12}, nearing exhaustion 8 years earlier than is implied by its expiration date (Figure 1).

As demonstrated in these examples, the value-creating potential lost due to SRD decreases when a resource erodes, holding constant its deployment and perishability. Therefore, how much a strategic resource decays in a given period also depends on how much it erodes due to external factors. The firm's acquisition of a resource and the resource's potential complementarity with the firm's existing resource base interact positively to affect the resource's value (Makadok, 2001). Our model suggests that the inverse is also possible: Both the exogenous erosion and the endogenous decay decrease the resource's value-creating potential, and their combined impact on the resource's value-creating potential is less than the sum of their individual effects. Since SRD threatens firm performance through exhaustion, we suggest that SRD poses a greater threat to firm performance and competitive advantage when a strategic resource is not subject to erosion or the rate of erosion is low. At high levels of erosion, strategic resources might become largely exhausted due to erosion long before the end of their potential lifespans implied by their depletability and perishability.

> **Proposition 3.** *Erosion of strategic resources attenuates the negative relationship between SRD and subsequent firm performance. All else constant, the higher the rate of erosion, the lower the impact of SRD on resource exhaustion and firm performance.*

4.3 | SRD and resource management

In analyzing how the firm can sustain competitive advantage while coping with exogenous changes, both the dynamic capability view[9] (e.g., Adner & Helfat, 2003; Eisenhardt &

[9]The dynamic capability view emphasizes dynamic capabilities, firm-idiosyncratic organizational processes and capabilities that enable the firm to respond to environmental changes and to affect its environment, as the source of sustainable competitive advantage. For a recent review, see Schilke, Hu, and Helfat (2018).

Martin, 2000; Teece et al., 1997) and the RBV research that utilizes resource-action-performance models (e.g., Hult, Ketchen, & Slater, 2005; Ndofor, Sirmon, & He, 2011) emphasize resource-related processes that link strategic resources to value creation. As addressed in the resource management framework (Sirmon et al., 2007), three broad processes—structuring, bundling, and leveraging—encompass the types of actions that can help the firm cope with external dynamism. Like external dynamism, decay-driven exhaustion can disrupt the fit between the firm and its environment, and these processes also explain how the firm can potentially mitigate the negative effects of SRD. In this section, we first discuss the most pertinent aspects of the resource management framework; this is followed by our proposition on how resource management might moderate the SRD–firm performance relationship.

4.3.1 | Structuring

Structuring involves investing in the acquisition of strategic resources in factor markets or in the accumulation of non-tradable strategic resources and divesting unproductive resources (Sirmon et al., 2007). In relation to SRD, investment driven by the decay of tradable strategic resources implies a search for substitutes to replace the decaying resource. Given that tradable strategic resources are scarce, to find viable substitutes, the firm needs to compete in factor markets and assess the future values of resources through the processes of "resource picking" (Makadok, 2001), "selecting investments" (Helfat et al., 2007), and "resource connoisseurship" (Breton-Miller & Miller, 2015). Because the outcomes of these processes are uncertain (Miller & Arikan, 2004), the firm can use a real-options approach to increase the chances of successful replacement by acquiring rights to alternative resources (Sirmon et al., 2007).

Investment driven by the decay of non-tradable strategic resources, in contrast, involves generating or acquiring fungible components that can complement the decaying resource in an effort to replenish it.[10] As previously explained, the firm may prevent the decay-driven exhaustion of a non-tradable strategic resource if it can replenish the resource by offsetting the decayed portion. On the other hand, the firm can mitigate potential sunk costs by divesting tradable strategic resources or generic components of non-tradable strategic resources that are nearing exhaustion as well as any other asset that is specialized to them.

4.3.2 | Bundling

Bundling refers to "the combining of firm resources to construct or alter capabilities" (Sirmon et al., 2007, p. 277), which are "the integration[s] of tangible assets, knowledge, and skills" (Helfat et al., 2007, p. 4). To utilize a newly acquired resource, the firm must first engage in bundling activity (e.g., onboarding a new employee or installing new equipment). To deal with SRD, the firm can create new bundles and capabilities that do not utilize the decaying strategic resource or can rebundle the decaying strategic resource with a different set of complementary resources and routines.

[10]The dichotomy of replenishment of non-tradable strategic resources versus replacement of tradable strategic resources, which we suggest herein, echoes Makadok (2001), who suggests that the firm's non-tradable capabilities and its effectiveness in factor market acquisitions are substitutes if there is low complementarity between the acquired resource and the firm's capabilities.

Bundling can lead to the creation of a new capability that replaces both a decaying strategic resource and the related capability.[11] For example, the depletion of bluefin tuna stocks and the regulatory pressures applied as a result (Food and Agriculture Organization, 2020) have motivated some large seafood companies to invest in "egg-to-harvest" farming capabilities to replace the wild fishing of this species (Takuya, 2016). However, firms often prefer to create bundles that utilize and complement their existing capabilities, resources, and knowledge (Helfat & Eisenhardt, 2004; Kogut & Zander, 1992). By rebundling a decaying strategic resource with different complementary resources, routines, or new knowledge, the firm can increase its value-creating potential. This new bundle can also lead to disruptive innovation (Galunic & Rodan, 1998). For example, Mitchell Energy rebundled hydraulic fracturing, a known but underutilized drilling technology at the time, with its existing reserves and know-how to gain access to enormous underground gas reserves in the Barnett Shale. This success laid the groundwork for the shale gas and oil boom in Texas, where the hydrocarbon reserves were considered nearly exhausted (Cahoy, Gehman, & Lei, 2012).

Rebundling can also create "new uses for existing resources" (Denrell, Fang, & Winter, 2003, p. 981), increasing the value-creating potential of a decaying strategic resource. For example, after playing for the Boston Celtics since 1956, Bill Russell became a player-coach for the Celtics in 1966. Before retiring as a player in 1969, he won the NBA title twice as a head coach. Further, even an exhausted strategic resource can gain new value when it is bundled with the right capabilities, such as exhausted coal mines that are used as sources of coalbed methane, a natural gas with economic value (Baker & Nelson, 2005).

4.3.3 | Leveraging

Once resources and complementary routines are bundled into capabilities, they must be leveraged in product markets to create value. Leveraging involves matching the opportunities in the market with the right set of capabilities and deploying those capabilities to support a chosen strategy (Sirmon, Hitt, & Ireland, 2011). Therefore, deployment is a necessary step in value creation and complements other resource management actions.

Leveraging its existing capabilities and the related decaying strategic resources by redeploying them in different market contexts can help the firm cope with SRD. Through redeployment, the firm can "respond to a threat to a capability in one market by transferring the capability to another market" (Helfat & Peteraf, 2003, p. 1006). Redeployment in a new product or geographic market (Anand & Singh, 1997; Kaul, 2012) can increase a decaying strategic resource's value-creating potential. For example, TV shows and formats are depletable resources that can lose their newness when they are deployed. However, production firms can redeploy old TV shows and formats in different countries, reaching new audiences, and potentially increase the value-creating potential of these resources. Further, if a strategic resource is scale free, the firm can redeploy it concurrently in multiple markets without incurring opportunity costs (Levinthal & Wu, 2010). Nonetheless, not all resources are flexible—that is, fungible across different product or geographic contexts (Combs, Ketchen, Ireland, & Webb, 2011). Because TV shows and formats are both flexible and scale free, production firms often redeploy

[11]The firm might subsequently retire an obsolete capability (Helfat & Peteraf, 2003) and divest the related resources, which involves unbundling the capability (Helfat et al., 2007).

them concurrently in different geographic markets, mitigating the negative effects of decay caused by depletion.

Based on the preceding arguments regarding the roles that resource structuring, bundling, and leveraging actions play in the SRD–firm performance relationship, we propose the following:

> **Proposition 4.** *Resource management actions of the firm can attenuate the negative relationship between SRD and subsequent firm performance.*

4.4 | Temporal properties of strategic resources and synchronization

The firm sustains competitive advantage against exogenous changes by reconfiguring its resource base and capabilities in congruence with the changes occurring in the external environment (Eisenhardt & Martin, 2000). Against SRD, it is important for the firm to manage its resources proactively in line with the endogenous changes in the value-creating potentials of its strategic resources. In an inter-temporally dynamic relationship, the firm must respond to or preempt SRD with resource management actions, which influence the extent and pattern of the decay the firm will subsequently face. We suggest that this relationship reflects three temporal properties of strategic resources: decay rate, variability of the decay rate, and remaining lifespan. The firm can mitigate the negative effects of SRD on firm performance by synchronizing—aligning the timing and extent of—its resource management actions with these three properties. In this section, we first define the temporal properties of strategic resources, and then present our proposition regarding the role synchronization plays in resource management.

4.4.1 | Decay rate

The values of resources "deteriorate or appreciate, over time, at varying rates of change" (Amit & Schoemaker, 1993, p. 36). A resource's decay rate indicates how quickly the resource endogenously loses its value-creating potential. In the competitive dynamics literature, the frequency of rivals' competitive moves and other external stimuli are the drivers of firm actions (e.g., Chen & Miller, 2012; Ferrier, Smith, & Grimm, 1999). Decay provides an internal cue for the firm to engage in resource management actions. To avoid exhaustion of the resource, the higher the decay rate of a strategic resource, the more intensively the firm must engage in resource management activity. For example, suppose two oil pipelines are identical except for their locations. If one corrodes faster due to the differences in soil properties in the areas where the pipelines are located, it has a greater decay rate than the other. In turn, its replenishment through maintenance will require more frequent firm actions and more investment than the replenishment of the pipeline with the lower decay rate.

Reconfiguration is costly (Teece et al., 1997), and managerial attention and effort are inevitably limited (Penrose, 1959). Thus, higher decay rates are likely to reduce the effect of resource management activity on the relationship between SRD and firm performance. However, low decay rates might also be problematic. Helfat and Peteraf (2003, p. 1005) suggest that "reduced utilization of a capability would degrade the level of capability." If a strategic resource has a very low decay rate, the firm could structure, bundle, or leverage the resource so infrequently

that organizational forgetting could occur (Thompson, 2007). This might weaken the firm's capabilities related to the resource as well as limit the firm's ability to manage SRD. Accordingly, a moderate decay rate can increase the efficiency and effectiveness with which the firm manages its strategic resources.

4.4.2 | Variability of decay rate

The variation in the decay rate of a strategic resource across time constitutes the "when" of resource management, and understanding this variation can enable the firm to time its resource management actions in accordance with the pattern of the decay and develop routines through entrainment. Entrainment is the alignment of two systems, such that the rhythmic movement of one system provides the tempo (frequency of action in a given period) for the other (Ancona & Chong, 1996). In the competitive dynamics literature, assuming that exogenous changes occur in rhythmic patterns, the firm entrains its activity to the tempo of stimuli such as rivals' competitive moves (Nadkarni, Chen, & Chen, 2016). However, these stimuli may be discontinuous (Hitt, Ireland, Camp, & Sexton, 2001; Schilke, 2014), and the firm's rate of activity can vary across time (Laamanen & Keil, 2008), implying that both stimuli to act and firm activity can be arrhythmic. Accordingly, we argue that to entrain firm activity to a stimulus, both the tempo and the rhythm of the stimulus should be considered.

Endogenous changes affecting strategic resources such as SRD can also occur in rhythmic and arrhythmic patterns. With SRD, the decay rate indicates the tempo—that is, the intensity with which the firm should act. The variability of a strategic resource's decay rate, on the other hand, indicates the rhythmicity of the resource's pattern of decay, according to which the firm should time its actions. If the decay rate has little or no variability, it is easier for the firm to establish routines because the pattern of the decay is rhythmic, repetitive, and predictable.

Since decay rates of perishable strategic resources do not vary across time, firms can build routines around them. For example, as previously explained, holding external factors constant, the decay rate of a patent does not vary across its lifespan. Consequently, the firm can reliably invest in the development and maintenance of capabilities (e.g., manufacturing or strategic alliance management) to commercially benefit from the patent. Nonetheless, perishable resources decay regardless of whether the firm deploys them. The firm cannot pause this process to find replacements or enhance its capabilities. This limitation also makes perishable strategic resources potentially vulnerable to discontinuous environmental changes (e.g., price shocks or supply chain disruptions) because the firm cannot defer their value-creating potential. Accordingly, if the firm fails to develop the necessary capabilities to utilize a patent on time, it will incur opportunity costs. Likewise, if a patent erodes due to exogenous changes, the firm cannot transfer the protection provided by the patent to another period during which the external environment might be more favorable (e.g., due to demand conditions or regulatory changes).

In contrast, the decay rates of depletable strategic resources may vary greatly depending on the firm's deployment activity. Routines and capabilities are not cost free (Helfat et al., 2007). Sporadic deployment can prevent the firm from achieving entrainment and make it harder and costlier to establish and maintain routines and capabilities. Yet, the firm can also hold depletable strategic resources without incurring opportunity costs when market conditions are unfavorable or when further resource structuring or bundling is needed. Operators of silver and

gold mines, for instance, often choose to suspend or decrease production when commodity prices decline (e.g., Reuters, 2019). Whether discretionary or not, a lack of deployment indicates that decay does not occur and, holding external factors constant, the resources retain their value-creating potential. Accordingly, depletable strategic resources offer greater flexibility in terms of the timing of their management.

4.4.3 | Remaining lifespan

The remaining lifespan of a strategic resource indicates the amount of time before it is exhausted. A resource's lifespan is negatively related to the speed with which it is depleted or perishes. However, the firm's resource management activity can increase as well as decrease the subsequent lifespan of a resource. For instance, while investing in the replenishment of a strategic resource may increase its lifespan, deployment causes decay if the resource is depletable. Therefore, to act synchronously with endogenous changes in resources, the firm should estimate the remaining lifespans of its strategic resources and continuously update this estimation. The remaining lifespan of a tradable strategic resource indicates the amount of time left for the firm to develop and deploy real options in lieu of the decaying resource before the resource becomes exhausted. Proactive resource management is critical to preventing the exhaustion of non-tradable strategic resources as well because they are subject to time compression diseconomies. Further, non-tradable strategic resources cannot be replenished unless the firm maintains a critical mass of them (Dierickx & Cool, 1989). Conversely, when the costs associated with replacing, replenishing, rebundling, or redeploying a strategic resource outweigh the potential benefits, the firm should opt for unbundling and divesting the resource.

These considerations regarding the temporal properties of strategic resources—decay rate, variability of the decay rate, and remaining lifespan—lead us to our final proposition:

> **Proposition 5.** *The effectiveness and efficiency of the firm's resource management actions in attenuating the negative relationship between SRD and subsequent firm performance depend on whether the firm actions are synchronized with the temporal properties of the strategic resources.*

5 | DISCUSSION

Our framework addresses an important theoretical gap by connecting the resource-based logic with phenomena endogenous to strategic resources. When SRD is ignored, strategic resources are assumed to be inherently static in value, provided that they are safeguarded from competition. Owing to this omission, the existing literature lacks a typology that classifies strategic resources based on their characteristics that are directly related to the sustainability of resource-driven competitive advantage (Kraaijenbrink, Spender, & Groen, 2010). Our contribution to the literature is threefold. First, our two-dimensional typology identifies the antecedents of SRD and expands the classification of strategic resources to include perishable, depletable, and perpetual resources, thereby illustrating how strategic resources endogenously lose their value-creating potential. Second, we develop propositions linking those characteristics to their performance implications. We propose two boundary conditions for the relationship between SRD and firm performance: tradability and erosion. Third, we explore how the firm can mitigate the

negative effects of SRD, and we define the temporal properties of strategic resources that are critical to the firm's success in this endeavor.

5.1 | Future research

Our framework has important implications for future RBV research. Empirically capturing the proposed negative relationship between SRD and firm performance would be an important first step in constructing a more complete picture of the sustainability of competitive advantage. Contrasting the effects of SRD between firms that utilize non-tradable strategic resources and those whose performance depends on tradable strategic resources could yield interesting findings as well. Because change is constant in the firm's external environment "to at least some extent" (Helfat & Winter, 2011, p. 1249), any empirical examination of SRD must also account for external dynamism. Otherwise, the effects of decay may be conflated with those of erosion.

Although the examples we provide involve linear patterns of decay, the relationship between decay and change in value-creating potential might be nonlinear for some resources. For example, oil and gas wells typically decay exponentially, as their exploitation is characterized by a rapid depletion, which gradually slows down until their exhaustion is complete. Human resources might also decay in a nonlinear fashion. For instance, age might be negatively correlated with human capital attributes such as creativity and physical fitness (Simonton, 1989). Accordingly, depending on the sport, the decay rate of a star athlete might be high around the time when the athlete's performance peaks. The athlete might then stay professionally active for years but fail to perform at a similar level, indicating a nonlinear pattern of decay. Future research on strategic resources could benefit from the exploration of nonlinear patterns of decay, both theoretically and empirically.

Synchronizing the actions addressed by the resource management framework (Sirmon et al., 2007, 2011) with the temporal properties of strategic resources we introduce is of vital importance in managing SRD. Future research would benefit from empirical investigations of the role that resource management plays in the relationship between SRD and firm performance, including a consideration of whether the firm's actions are synchronized with the temporal properties of strategic resources. Further, we need to better understand how firms develop insights about the temporal properties of their strategic resources, especially those that are new to the firm.

At present, there is a gap in the RBV literature regarding the processes through which intangible resources originate, evolve, and influence firm performance (Molloy, Chadwick, Ployhart, & Golden, 2011). Decay is a salient process in regard to the relationships between intangible resources and firm performance. Further, there seems to be an agreement in the literature that all intangible resources are perishable and that they are not depleted with usage (e.g., Chang & Hong, 2000; Molloy et al., 2011). Conversely, our framework suggests that some intangible strategic resources are depletable and that some tangible strategic resources are perishable. The concepts of perishability and depletability explain the mechanisms of decay consistently across tangible and intangible resources. A reexamination of intangible strategic resources such as human capital with a consideration of SRD may help researchers clarify the elusive relationships between intangible resources and firm performance.

Our framework also has implications regarding firms' boundary choices. The existing research linking the resource-based logic to transaction cost economics emphasizes the firm's decisions to integrate certain resources and activities in an effort to prevent opportunistic behavior by the external owners of resources (e.g., Argyres & Zenger, 2012). However, our framework suggests that

some tradable strategic resources, such as recording contracts or operating rights, might support competitive advantage and prevent value appropriation only for a certain period of time. Upon their decay-driven exhaustion, the firm might face the risks of value appropriation and intensified factor market competition. Future research could examine both the boundary choices regarding these types of strategic resources and the role SRD plays in these choices.

5.2 | SRD and dynamic capabilities

Although we emphasize its potentially detrimental effects on firm performance, SRD can also be an antecedent of dynamic capabilities. While prior work emphasizes how firms develop dynamic capabilities by learning through experience to respond to environmental changes (Schilke et al., 2018), a similar logic extends to the endogenous decay. First, SRD has the potential to disrupt the fit between the firm's internal and external environments from within, thereby providing a stimulus for the firm to reconfigure its resources and capabilities. Further, resource management activities, in which the firm needs to engage to mitigate the negative effects of SRD, imply opportunities for the firm to learn about its strategic resources through experience. Resource learning—that is, hands-on learning about specific characteristics of resources (Mahoney, 1995)—can enhance the firm's subsequent resource management activities and evolve into dynamic capabilities over time.

Eisenhardt and Martin (2000, p. 1107) define dynamic capabilities as "the organizational and strategic routines by which firms achieve new resource configurations as markets emerge, collide, split, evolve, and die." SRD constitutes an alternative explanation as to why the firm might need dynamic capabilities, even in environments that are not characterized by rapid change. Likewise, Helfat and Winter (2011) suggest that upstream oil and gas firms' capabilities to replenish their reserves qualify as dynamic capabilities. Future research could benefit from the analysis of SRD along with environmental dynamism to foster a more complete understanding of the origins of dynamic capabilities.

Although SRD poses a potential threat to strategic resources, a lack of exposure to SRD can weaken the dynamic capabilities of the firm. Dynamic capabilities involve repetitive actions and processes that are path-dependent. SRD, due to its relatively predictable and continuous nature, provides an avenue for the firm to maintain and hone its dynamic capabilities over time by utilizing them on an ongoing basis. Accordingly, firms that have successfully dealt with high decay rates and resource exhaustion over longer periods might also be more robust to rapid exogenous changes. On the other hand, firms that have not recently been exposed to SRD might be vulnerable to environmental changes. The existing dynamic capabilities of the latter firms might have become weaker due to a lack of utilization. Future research could also benefit from an empirical analysis of the relationship between past exposure to SRD and robustness to external dynamism.

Innovation is one of the most frequently studied outcomes of dynamic capabilities. As previously discussed, firms might be able to deal with the threat posed by SRD by rebundling their decaying strategic resources with new or existing knowledge. In the case of Mitchell Energy, the innovation that kicked off the most recent oil and gas boom in Texas resulted from learning through experience about a geological structure for over a decade (Cahoy et al., 2012), which enabled the firm to maximize the value-creating potential of a decaying resource base previously thought to be near exhaustion. Accordingly, studying the relationship between SRD and innovation could be another fruitful research avenue.

5.3 | Implications for practitioners

To sustain a resource-driven competitive advantage, managers should first evaluate the resource base of the firm and understand the types of strategic resources the firm possesses as per our typology. Unless the firm derives its competitive advantage from perpetual resources, it must then take appropriate resource management actions. Both the types of actions managers should pursue and the extent and timing of these actions depend on the inherent characteristics and the temporal properties of the resources. The tradability of a strategic resource indicates whether there may be a possibility of replenishing the resource rather than replacing it. To deal with the threat posed by SRD, it is critical for the firm to achieve synchronization between its resource management actions and the temporal properties of its strategic resources. To achieve this synchronization, managers must understand the mechanisms underlying the decay of strategic resources—namely, depletability and perishability.

Perishable resources decay without variation in their decay rates, so they are inherently more suitable for routinization of resource management activities through entrainment than depletable resources are. However, perishable strategic resources might also be more vulnerable to exogenous changes, as their value-creating potential cannot be deferred. Therefore, firms that operate in high-velocity or turbulent industries might consider contracting or outsourcing certain activities instead of internalizing them and investing in perishable strategic resources. In such environments, depletable strategic resources might be more advantageous since the firm can defer their value-creating potential when market conditions are not favorable. At the same time, sporadic deployment and a highly variable decay rate can weaken the routines and capabilities related to a resource. Therefore, especially in dynamic environments, the firm could benefit from managing depletable strategic resources in an ad hoc manner (Winter, 2003) rather than focusing on capability building and routinization through entrainment. In dynamic environments, strategic resources can erode rapidly due to external factors, such as imitative or innovative hypercompetition, and quickly become exhausted no matter how fast they decay. Accordingly, in such environments, SRD might be a less salient threat to competitive advantage and firm performance, and firms might be better off investing in the creation of new capabilities rather than in the replenishment or replacement of decaying strategic resources.

6 | CONCLUSION

Most strategic resources are subject to the forces of decay (i.e., time and deployment), due to which they can become exhausted. SRD threatens firm performance through resource exhaustion. The firm can prevent the exhaustion of non-tradable strategic resources through replenishment. However, to counter the threat posed by the decay of tradable strategic resources, the firm needs to replace, rebundle, or redeploy these resources. Erosion of strategic resources is another antecedent of resource exhaustion. It attenuates the negative SRD–firm performance relationship such that the higher the rate of erosion, the smaller the subsequent value-creating potential of a strategic resource, and therefore the lesser the extent of SRD will be. The firm can mitigate the impact of SRD on firm performance if it takes the appropriate resource management actions in synchrony with the temporal properties of the strategic resources.

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DATA AVAILABILITY STATEMENT

Data sharing not applicable to this article as no datasets were generated or analyzed during the current study.

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