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An analytical framework to compare innovation strategies and identify simple rules

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ABSTRACT

Innovation strategy is a context specific set of choices towards a goal that is underpinned by strategic logic. We link three archetypal innovation strategies via an analytical framework covering four dimensions- 'objectives', 'scope', 'advantages', and 'flaws'. We argue that such a framework is currently non-existent and enables innovation strategy comparisons on a common basis. Patterns in the 'disruptive', 'modular', and 'enabling' innovation archetypes, help draw out simple rules for proactive innovation strategy. Thus, the theoretical contributions of this paper are two-fold- (a) the introduction of a novel analytical framework to characterize innovation strategies, and facilitate their comparison on common basis; and (b) the pattern-driven discovery of simple rules for three innovation types, thereby contributing to the emerging theory of strategic heuristics.

1. Introduction

Innovation strategy is conceptualized as levers pursued by managers to innovate (Crossan and Apaydin, 2010; Foxall and Johnston, 1987; Klingebiel and Joseph, 2017; Miller and Friesen, 1982; Soetanto and Jack, 2016; Tipping et al., 1995), and has impact on firm performance (Cooper and Edgett, 2010; Erzurumlu, 2017; Hall and Bagchi-Sen, 2007; Pearson, 1990; Tidd and Bessant, 2018). Yet, setting strategy is complex because choices are idiosyncratic and context dependent (Drazin and Van de Ven, 1985; Nath and Sudharshan, 1994; Venkatraman and Camillus, 1984). Theory building from cases is also complex as causality is not straightforward to determine restrospectively. As a result, interesting questions of relevance to strategy have not been explored, because we do not possess the adequate tools to theorize across causally complex phenomena (Meyer et al., 2005; Misangyi et al., 2016).

However, an emerging theory of strategic heuristics (Bettis, 2017; Eisenhardt and Sull, 2001; Maitland and Sammartino, 2015) suggests that strategists experientially learn simple rules (Bingham and Eisenhardt, 2011a; 2011b), which serve as decision making tools in complex business environments. This paper explores the strategic decisions associated with well-studied archetypal innovations to identify patterns of simple rules or heuristics for innovation strategy.

To do this, we need to address the issue of non-comparability of strategies. The discourse on strategy lacks a construct to compare and contrast two strategies consistently. We therefore develop an analytical framework that captures strategic choices and the logic guiding them. It enables systematic comparison of strategic choices, and links the seemingly disparate strategies of seemingly disparate innovation forms. We suspect that without such a consistent analytical framework, comparing strategic decisions is haphazard, confusing, and not fruitful in yielding simple rules.

The framework is founded on prominent literature streams including the complexity view (Chakravarthy, 1997; D'Aveni, 1995; Eisenhardt, 1989b) and the resource-based view, which regards strategic choice making as a dynamic capability (Eisenhardt and Martin, 2000). Specifically, the concepts of industry value chains (Kaplinsky and Morris, 2000), value-centric view of the business (Amit and Zott, 2001; Baden-Fuller and Haefliger, 2013; Liu et al., 2021), and competitive value (Porter, 1997) shape the framework. Methodologically, we use the scholarship of integration for framework development (Bartunek, 2007; Boyer, 1990), and three cases and inductive logic to build theory (Eisenhardt, 1989a; Ketokivi and Choi, 2014).

In the following sections, the analytical framework is developed by drawing on the typology of strategic logics (Bingham and Eisenhardt, 2008; Lengnick-Hall and Wolff, 1999) and connecting it to contextual decision variables. Next, three well-discussed and distinct innovation forms are presented in depth and the framework is applied to highlight the variations in context and strategic choice. The historical and

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technical contexts of each case are presented. This is followed by a discussion of the strategic choices that made it successful. Thus, the framework organizes the technical, commercial, and organizational components of each innovation, links each innovation to the context, and facilitates cross-comparison. In doing so, the key questions leading to simple rules for these three innovation forms are drawn out. Thus, the framework links distinct innovations and highlights specific simple rules important to theory and practice. The paper contributes to the emerging theory of strategic heuristics via application.

The following innovation forms are studied: 'Uber' as a disruptive innovation in the 'ground transportation' industry; the 'gear system module' in the 'bicycle' artifact as a modular innovation; and Corning Inc.'s 'low-attenuation fiber optic cable' technology as an enabling innovation in the 'communications' industry. While innovation typology research has yielded several archetypes (radical, architectural, and competency destroying innovations to name a few), our choice is motivated by three reasons. The first is that the selected archetypes have been extensively convered in the literature and are well debated and well understood to a level of detail necessary for framework application and to draw out meaningful simple rules for their proactive implementation. Second, the selected archetypes comprehensively cover both the technological aspects and their strategic imperatives for managers. Said differently, they are more complete in their definitions, which leads to more meaningful insights. Cases for other innovation forms with the same level of technical and strategic depth were not found. Lastly, the choice of 'three' cases and not fewer or more is driven by a desire to balance detail and space limitations. Fortunately, this limitation creates a healthy future research opportunity to further test the strategy framework and improve it via application to different cases and innovation archetypes.

2. Framework development

The resource-based view (RBV) relates firm objectives to the ownership of resources (Barney, 1986; Penrose, 1959; Peteraf, 1993) and the dynamic capabilities (DC) paradigm studies strategic decision making as a specific and identifiable process (Eisenhardt and Martin, 2000). RBV and DC have significantly shaped recent thinking on strategic decision making for competitive advantage, innovation, and growth (Teece, 2009). Even in the case of innovation management, while contemporary innovation models fail to explain across or within sector innovation outcomes (Hobday, 2005; Mahdi, 2003), the proposal that "resource investments and organization structure enable a non-linear divergent-convergent innovation cycle" (Van de Ven, Polley, Garud and York, 1999) reflects the foundational role of the resource-based view.

These paradigms have yielded literature on innovation strategy that has largely been idiosyncratic (Christmann, 2000; Lei et al., 1996; Teece, 1998; Tidd et al., 1997). The literature contains rich descriptions on strategic choices and why they successfully yielded superior firm performance in specific contexts, yet there does not exist an analytical framework to consistently lay out components of an innovation strategy. As a result, discussions on innovation strategy are insightful, but not general or comparable across strategies. To derive genralizable insight, we must link contextual nuances and strategic choices to the underlying strategic logic, which can then be applied to data (e.g., via case studies in this paper) for specific pattern recognition.

General strategy frameworks (Kim and Mauborgne, 2002) or those belonging to adjacent research areas such as business model research (Afuah and Tucci, 2003; Casadesus-Masanell and Ricart, 2010; Osterwalder and Pigneur, 2010) apply only vaguely to innovation strategy and fail to characterize its nuances, because they focus on specific parts of implementing innovation (e.g., customer value proposition) (Kim and Mauborgne, 2002; Osterwalder et al., 2014; Rintamäki and Saarijärvi, 2021). They are either too specific or too simplistic, and fail to compartmentalize strategic choices and related logic. As a result, they do not address the issue of non-comparability of innovation strategies raised above. Thus, an analytical framework to compare innovations consistently, and strategies more broadly, is needed. An ideal framework should provide schema-like generalizability (Rumelhart, 1980, 1984), and define relationships that are general enough to be applied across innovation archetypes, and at the same time, specific enough to clearly articulate the differences between innovations (Rosenman, 1993). We develop a framework consisting of these attributes below.

Strategy is explained as a set of choices towards an objective (Casadesus-Masanell and Ricart, 2010; Caves, 1984; Porter, 1996b). Thus, strategy setting is the process of choosing 'where' to compete and 'how' to compete, and by inversion, it involves making trade-offs regarding where *not* to compete, and how *not* to compete. Hence, a strategy creates organizational focus (Kim and Mauborgne, 2002) such that managers recognize choices within and outside bounds (Collis and Rukstad 2008).

Further, a strategy should have specific advantages that help it achieve competitive differentiation. Collis and Rukstad (2008) propose a suitable structure that we adopt for the analytical framework developed in this paper. The high-level dimensions - 'objective', 'scope', and 'advantage' are suitable as they are "simple yet sufficient for any strategy that addresses competitive interaction over an unbounded terrain." We add the fourth dimension of 'flaws' because strategic choices are resource dependent and therefore, involve making trade-offs. Further, strategic choices are based on partial or incomplete information, leading to uncertainty and risk. Lastly, owing to inherent complexity, seemingly well-separated choice dimensions are also highly likely to cause cross-variable effects. Therefore, it is only prudent to say that all strategies undoubtedly contain tradeoffs or disadvantages, which we broadly cast as flaws.

The value-centric view of strategy, which reinforces value exchange as the core of a business, is adopted to develop the individual components within each category of the strategy framework. Liu et al. (2021) recently conducted a thorough literature review condensing strategy components into a system view underpinned by the value-centric concept (A. B. Sheth, 2021; A. Sheth and Sinfield, 2019). It includes the management, protection, and sustenance of business value and defines functions to identify, create, convey, deliver, and capture value. These, along with other value-centric views such as value from competitive advantage and a firm's positioning in the value chain, help build components falling under the 'objective', 'scope', 'advantage', and 'flaws' strategy framework.

In principle, the objective dimension relates to an innovation's purpose and mission, i.e., the 'what' and 'why' questions such as *what is the mission? what problem does the innovation solve? and what value is created?* The objective should yield a precise time-bound goal for the innovation and explicitly indicate how it compares to a point of reference. We breakdown 'objective' into two components- (a) the vision, which is a view of the future state assuming innovation success, and (b) the relative performance goal, which compares how the innovation would perform as compared to an alternative choice (e.g., another innovation or attributes of an alternative/competitive offering). Both components are part of the strategy setting philosophy initiated by Michael Porter (1996a, 1997). Overall, a strong objective dimension should articulate a time-bound and differentiated goal that is aligned with the strategic intent of the enterprise's business or competitive strategy, i.e., its absolute performance goal (e.g., increase market share by a certain percentage, increase consumption by a specific customer segment).

The scope dimension is about the specifics of the 'where' and 'how' questions such as *which markets should be pursued? how to enter these markets? how to penetrate them in the intended time? and how to price relative to competition?* As described originally by Collis and Rukstad (2008), scope covers strategic choices related to 'customer' or 'offering', 'geographic location' or 'specific choice of markets', and 'vertical integration'. While the categories are broadly applicable, they are not

separated with enough resolution to articulate nuanced innovation strategy. For instance, choices related to markets such as the customer and price points contain sub-layers that overlap. Market price points can vary by location, whereas the decision to vertically integrate impacts price and has much to do with the capability and competitive advantage of integrating. However, we agree with the principle that scope determines the *boundaries* outside which the innovation strategy should not seek to create an impact, and within the boundary, the broad ranging set of questions should be addressed. We operationalize these as (a) Investment risk, i.e., the appetite and propensity of risk taking on part of the innovators; (b) Price relative to other comparable offerings or innovations, i.e., interrelated strategic choices that fundamentally place an innovative offering among a peer group and differentiate it from other non-comparable offerings; (c) Market dynamism, which captures the level of change in the market especially with respect to forces external to the firm such as long- and short-term trends; (d) Industry and customer, which breakdown choice of target industry and determine whether the offering is applicable to more than one industry; (e) Purpose-context (A. Sheth and Sinfield, 2021), which provides opportunity to hyper-segment the core group of customers that can potentially benefit from the innovation; and (f) Market capture channel, which relates to choices regarding ways to reach the targeted customers.

Scope incorporates choices like vertical integration or forward integration and thus, is rooted in the well-established notion of a value chain or network. As described by Kaplinsky and Morris (2000), the *risk of investment* closely relates to the range of activities conducted in the value chain. Similarly, value identification described by Liu et al. (2021) includes understanding the *industry* and the *customer* and their specific *purposes-contexts* to build a focused offering. Further, *relative pricing* is a key determinant of the value management and value capture business functions, as pricing determines revenues re-entering the business. The value convey and delivery functions support the choice of *customer outreach and marketing channel*. Overall, the scope dimension lays emphasis on what is within and what is outside the bounds of the innovation, with a focus on going beyond singular dimensions of scope such as 'operational strategy' and 'market segmentation'.

In principle, the advantage dimension addresses why a strategy will reign superior over competition. Thus, it relates to the outcome or likely effect of choices on both indirect and direct competitiveness. More broadly, it tackles the 'what might' and 'what if' questions such as *the challenges to adoption by potential consumers* asking "are there significant barriers to adoption of our offering for consumers?" and by implication "how can adoption be improved?" It also evaluates *customer perception and sentiment* as an advantage of the strategic choices, and if those should be modified to generate a different more advantageous perception. From the perspective of direct competitiveness, it draws on insights traditionally developed in competitive strategy inquiring whether the innovation creates barriers to new entrants, if it involves supplier/value chain alliances or leverage, and if it limits the capital at risk. In other words, it defines the *basis of competition* for the category of the offering and highlights the complementary fundamental questions of "how to link the offering to greater value?" and "can this be done from a resources and capabilities perspective?" Thus, the focus here is offering and capability-centric in addition to being market and customer-centric. Traditional frameworks tend to largely focus on the customer value. For instance, the notion of 'customer value proposition' asks "*why would a customer choose the offering over competing offerings?*" but takes as given that the capability to provide the offering exists. While this could work with business model innovation, it is unlikely for archetypal innovation strategies.

Lastly, strategic 'flaws' could relate to inaccurate thinking, under/over doing activities that have worked, or wrongly interpreting signals. Thus, it is important to seek out the *likely pitfalls* via the framework. Table 1 shows the full set of questions across four dimensions.

Table 1
The components of the innovation strategy framework and corresponding action-oriented cues.

Strategy framework dimensions		Action oriented cues of significance to decision makers
Objective	Vision	Why do we exist? What is our purpose?
	Relative performance goal	How should the performance of our innovation compare to current status-quo/competitor offering?
Scope	Investment risk	What is our appetite and propensity for risk? Can we handle potential changes in risk?
	Relative price	How should we price our offering relative to competing offerings?
	Market dynamism	What is the dynamism of the target market in terms such as its competitive landscape, consumer trends? What can be expected of it in the near and long terms?
	Industry and customer	Do we target one or more industries? Who are we serving?
	Purpose-context	What customer purpose in what customer context does our offering satisfy? How do target customers purposes coevolve with their contexts?
	Market capture channel	What channels best enable us to reach our target market? Do we employ customer-specific channels? Should we change our market capture channels?
Advantage	Adoption advantages and challenges	Will there likely be a natural adoption of our offering? What barriers to adoption does our offering face?
	Effect on customer perception of performance	How do potential customers perceive our offering?
	Basis of competition	Are we capable of shifting the basis of competition for the value being delivered to market? How?
Flaws	Likely pitfalls	What are the key assumptions and potential pitfalls associated with our strategic choices?

2.1. Logic underpinning a strategy

According to the RBV, resource allocation governs competitive advantage. Thus, a firm's strategy, i.e., a set of choices in specific market conditions, should be underpinned by some logic to strengthen the firm's ability to succeed in that environment. We use logics proposed in the literature (Bingham and Eisenhardt, 2008) to demonstrate the validity of our analytical framework in comprehensively capturing the logic supporting a strategy and successfully facilitating cross-comparison of strategic logics. Additionally, the framework's action-oriented cues are useful in converting strategic thought into action. Put differently, the analytical framework accommodates the 'when' and 'why' questions of the context and logic, and facilitates the 'what' question needed to drive choice making. Thus, overall it comprehensively fills the gap highlighted in the sections above. The same cannot be said of other popular frameworks in adjacent fields. Table 2 shows all dimensions of the framework capturing the nuances of the three logics.

The 'position' logic addresses winning strategy for firms in non-dynamic markets, where the vision is to build interdependent resources into an activity system such that each resource enhances the collective value of the system in terms of *uniqueness* and *imitability*. This in turn leads to value differentiated offerings reflected by pricing choices. The risk associated with individual resources is initially low and multiplies as interdependencies increase. The position logic naturally yields a wide customer base, yet sometimes benefits may not be apparent before the system *densifies*. Strategists pursuing the position logic must caution against non-synergistic resource investments, while being aware of radical changes seemingly beyond scope.

In comparison, the leverage logic addresses winning strategy for

Table 2
Strategic comparability framework components derived from three strategic logics.

		Objective		Scope						Advantage			Potential flaws
		What is the main objective of the logic?		What is the scope of the logic? In which types of environments does the objective of the logic hold?						What key advantages can be drawn from the logic?			What are the pitfalls associated with this logic?
		The vision	Performance goal (relative)	Investment risk	Price (relative)	Market dynamism	Industry and customer	Purpose-context (need) co-evolution	Market capture channel	Adoption advantages or challenges	Consumer perception	Basis of competition	
Strategic Logic	Position	To build interdependent (linked) resources into an 'activity system' such that each resource enhances the collective value of the 'activity system'	Activity systems should enable advantages surrounding 'uniqueness' in the form of a 'differentiated' product or 'cost-leadership'	Individual resources are mundane and capital risk is low, especially when acquisitions are well planned. However, with each new acquisition, risk multiplies	Unique positioning will likely be well-leveraged. Prices may be higher if uniqueness is delivered by differentiation, and lower if by cost-leadership	Relatively stable market with very little dynamism		Dense activity systems should address several customer purposes in a few customer contexts	Selective marketing channels targeting intended customers are necessary	Uniqueness of offerings leads to natural adoption, but benefits may not be apparent to customers until tried (e.g. to appreciate the benefits of the Apple ecosystem, one needs to be initiated)	Customers are likely to recognize advantages gradually as the activity system densifies. Thus, consumer perceptions need to be guarded initially and maintained later on	Shift the basis of competition by capturing 'unique' value that is complex and inimitable, and continue to reinforce the uniqueness of position through complementary and densely-linked resources.	Unplanned or non-synergistic acquisitions. Loss of organizational processes to competitors Radical changes in the business environment Piecemeal changes to activity resources
Strategic Logic	Leverage	To build core resources, preferably knowledge-based	Core and non-core resources 'may' enable performance improvements	Core resource development will likely be capital intensive	Core resource will likely be well-leveraged	Moderately dynamic market marked by regular but predictable and incremental change	Core resources should be applicable in more than a single industry and to more than a single set of customers	Core and non-core resources should address changing/stagnant customer purposes in evolving customer context	Accurate choice of marketing channel corresponding to the target customer	Natural adoption unlikely. Non-core resources should adequately promote adoption to activate the leveraging opportunity	Non-core resources should actively change consumer perception	Shift basis of competition using the VR(I)N nature of the core-resource	Tendency to rely on exploitation of existing resources and inadequate exploration of new core resources Inability to exploit core resources in other markets
Strategic Logic	Opportunity	To develop flexible, loosely linked organizational processes to capture attractive fleeting market opportunities	Performance should correspond adequately to market opportunity, not come below expectations and not necessarily exceed them	The investment risks are least as the capabilities are semi-structured, and their loose linkage does not add multiplicative risk	Prices will likely be high as the logic is for attractive opportunities, i.e., those with higher revenues and profit margins	Highly dynamic markets marked by the rapid flow of attractive opportunities	Dynamic capabilities are embedded in the firm's nature and are likely to be applied across industries and customers	Capabilities should address few customer purposes in several customer contexts	Marketing channels corresponding to the target customer are important	The likelihood of several competing offerings is likely and thus, adoption may be a challenge	Consumer perceptions are not directly affected but built overtime	Shift the basis of competition by developing semi-structure organizational processes in the form of 'simple rules' to capture attractive value opportunities	Maintaining the adequate semi-structure (an abstract concept) Adapting slowly to market changes Misjudging temporary competitive advantage as sustainable competitive advantage

firms operating in moderately dynamic markets, where the underlying vision is to build core resources leading to improved performance. The focus is on developing core resources applicable to one market and *leveraged* in other markets with or without the help of other non-core resources. The value and inimitability of the core resource reflects in pricing, and its ability to pair with non-core resources governs the choices of industry and customer segment. The leverage logic can rely heavily on exploitation, leading to an inadequate exploration of new core resources.

Lastly, the opportunity logic addresses winning strategy for firms operating in highly dynamic markets and envisions the development of flexible learning and adaptation processes that can enable rapid value capture. The performance goals are commensurate to the opportunity, and typically firms seek to capture high-stakes opportunities quickly, not choosing but rather evaluating industries and customers associated with the opportunity. Success leads to short held competitive advantage, which may be misjudged as sustaining, whereas failure is attributed to not adapting quickly enough (often traceable to the inability to maintain the adequate flexible dynamic capabilities).

Table 2 compares the three strategic logics capturing the objectives, scope, advantages and flaws associated with them. As visible, the three logics address the contexts in detail (why and when) but do not adequately capture actionable steps (what). For instance, they tell us that the opportunity logic is suited to a dynamical context as compared to the leverage or position logics, which are suitable for less dynamical contexts. However, the logics by themselves do not specify the choices a strategist should make to capitalize on the given context. Therefore, having our analytical framework enables us to augment the what and why with the how. It provides us with the necessary tool to deepen the discussion to the level of 'strategic action', seeking to explain 'what should/can a decision maker do' and 'which discrete choices are available'. Thus, we develop a more granular and better characterized view of strategies useful in broadly comparing them, and paving the way to seek action-oriented simple rules (heuristics) for innovation strategy.

Below, we employ the analytical framework to explore strategies associated with three archetypal innovations. Each case study is divided into three parts: First, the technical and historical context of the innovation is described to understand the innovation archetype. Second, the related strategic choices and implications are discussed. Third, emerging tracks of managerial enquiry and simple rules for strategy are drawn. The first and second parts are in prose whereas the third is presented as a table at the end of each case study.

3. Three archetypal innovations

3.1. Uber's disruption of the taxi industry

Disruptive innovations have been the subject of rigorous scholarship (Abernathy and Clark, 1985; Adner, 2002; Anthony et al., 2008; Charitou and Markides, 2003; Christensen and Bower, 1996; Christensen and Raynor, 2013; Christensen et al., 2015; Clark, 2003; Danneels, 2004). There is noted debate on this innovation form including about a lack of completeness of understanding (Markides, 2006), the translational loss of crucial subtleties (Christensen, 2006) resulting in general misunderstanding of 'disruptions' and leading to an inaccurate strategy (Hopp et al., 2018; Hopp et al., 2018). Notwithstanding, disruptive innovations are highly specific (Choi et al., 2020), with precise contextual dependencies and exact mechanisms (Christensen et al., 2015). They contrast sustaining innovations, which are constituted by incremental and radical improvements. While incremental innovations introduce marginal improvements and radical innovations introduce substantial improvements (Balachandra et al., 2004), both do so along the same dimensions of performance as their predecessor offering. In contrast, disruptive innovations differ in their strategic intent.

Disruptive innovations (both low-end and new-market disruptions) are specialized innovations made with the objective of producing a lower-than-best performing product that offers a section of the market (which is often the least valuable to incumbents) additional value in at least one performance dimension that the high-performance product does not provide. The disruptive offering is generally priced lower than the highest-performing products for low-end disruptions and could be priced higher than alternatives (if any) for new-market disruptions. Such innovations are called disruptive as they start out serving the non-customer, who can either be from the unserved (new-market disruption) or overshot (low-end disruption) customer-segment, which has an unresolved need for the product. With this segment as the market entry point, the disruptive solution improves performance across dimensions, thereby gradually moving upmarket. While the process of market capture ensues, disruptors tend to be ignored by incumbent competitors as the disruptor's offering is presumed to be non-consequential to the incumbent's most valuable customers. Disruptors often pursue new channels to deliver their offerings, which allows them to operate, at least initially, with little competitive response. By the time incumbents recognize them as a significant threat to their businesses, they successfully 'disrupt' the incumbents.

The strategic intent of disruption is to change the basis of competition by providing 'good enough' performance on standard performance dimensions, while adding novel performance dimensions not available in the market, using new channels and moving upmarket undetected. This is distinct from radical innovations, where the strategic intent is to advance the basis of competition by substantial technological improvement that dramatically improves performance along traditional performance dimensions for existing customers. Thus, while sustaining innovation (incremental and radical) looks to maintain profitability and market share, disruptive innovation captures ignored customer segments and grows thereon.

3.1.1. Viewing Uber's disruptive innovation through the strategy framework

Uber Technologies is a prime example of a low-end disruption. Traditional taxi companies operated on a single-sided market, i.e., their customers were solely riders who wanted to commute from point A to B. In comparison, Uber's platform enabled a two-sided market, where its customers are both the rider/passenger as well as the car owner/driver. Uber's platform facilitated the connection between drivers and passengers and unlocked the latent capacity of underutilized cars in an area. In doing so, it provided its customers with first and foremost *convenience*.

Typically, car owners who desire to provide services, register their vehicles with Uber. Riders order their ride from a *well-designed app* that provides them choice of vehicle, information regarding the vehicle, the driver, approach and wait times, a driver-passenger rating system, and the approximate fare. Furthermore, passengers get a door-to-door commute and the rides may also turn out to be cheaper than the traditional taxi.

Before Uber's services, the performance goals for a taxi company included owning the largest fleet and serving the most customers. A customer-centric performance goal was to provide the best vehicle (e.g. Limousine) with the best chauffeur. The taxi service industry was a highly-regulated industry providing standard cars with standard drivers who were required to go through rigorous background checks before being issued an operating permit. While Uber underperformed on these traditional performance dimensions, its popularity soared based on the addition of several new performance dimensions that helped it shift the basis of competition. First, it focused on providing all customers with an option to choose from a fleet of vehicles *good enough* as compared to taxicabs, which traditionally segmented markets by cliental and attempted to improve performance for only the higher paying customers. Taxicabs had limited performance improvement criteria for the customers (riders), and drivers were hired leaving no scope to capture latent capacity. As a result, taxis were not distributed but concentrated in high-demand areas. As compared to this, Uber's platform traded-off rigorous driver screening (initially) and unlocked latent capacity, thereby increasing Ubers in an area. In combination with the app, this

enabled *on-demand ride-hailing*. Additionally, Uber's ability to attract riders on their platform allowed *ride-sharing*, thereby reducing per ride cost for passengers travelling in similar directions and willing to share rides.

Besides the option to pick one's vehicle, key improvements in performance were on the fronts of *convenience* and *reliability*. Uber's well-designed app provided a convenient way to check availability, select a car, view the driver's service rating from previous passengers, track locations, and prepay for the service, thereby saving the inconvenient and wasteful 15–30 seconds at the end of each ride. Furthermore, in case of non-satisfactory performance, the customer could report this immediately, thereby creating a continuous *feedback mechanism*. These attributes were unheard of with traditional taxi services whose reliability was perennially uncertain. Uber provided performance improvements at comparable prices to traditional taxi service providers. Uber drivers too could choose to serve customers or not based on location, passenger ratings, and additionally sell auxiliary products such as electronics or last-minute gifts, effectively generating extra income besides fare and tips.

Uber's original offering was meant to serve customers who were dissatisfied with traditional taxis and did not want to pay premium prices for top end services; customers who were likely to reduce their use of taxis by perhaps using public transport or their own vehicle. Uber targeted these underserved and overshot customers with ride-hailing and ride-sharing. Today, Uber has penetrated the high-end of the market by a variant service called the Uber-black that uses only commercially registered and insured livery vehicles and costs more per ride but provides the performance sought by the higher-end of the customer spectrum. This indicates Uber's trajectory from a low-end entry to more premium customers and its attempt to grow its share of the market. Furthermore, what began as a pilot experiment with few drivers in New York, gradually spread to other cities, allowing very little time for incumbent services to react and strategize to block their growth. Typically, taxis are part of unions powerful enough to arm-twist policy makers to stop competition or create legal barriers. Uber circumvented this by their choice of an app as the channel to market that allowed them to *remain under the radar* of most traditional competition, which either depended on pre-bookings or circled roadways to get passengers. Hence, yet another characteristic of disruptive innovations is their careful and protected initial market capture, which generally tends to be the unserved market, followed by either a gradual or as in Uber's case-a high-speed takeover of the larger market. Thus, we see that Uber's strategy fits that of a low-end disruption.

The key features of the disruptive innovation archetype are listed below. Furthermore, Table 3 provides the characteristics of the disruptive innovation archetype along the components of strategy, thereby revealing simple rules for strategists implementing disruptive innovations.

1. Disruptive innovations are *industry specific*
2. Disruptive innovations lead to products that *target niche customers*, typically those who are underserved or overshot by the current offering, and who have the willingness to pay
3. Disruptive innovations *shift the basis of competition* by providing additional dimensions of performance as compared to the traditional dimensions, while giving up on some traditional performance dimensions
4. Disruptive innovations lead to products that are *typically lower priced* than the current offerings for low-end disruptions and *could be higher priced than alternatives (if any)* for new-market disruptions
5. Disruptive innovations *use new or non-traditional go-to-market channels,* thereby avoiding direct competition with incumbents for as long as possible
6. Disruptive innovative technologies themselves are initially unattractive to large players as they do not provide sufficient profit margins required by the larger players to justify expenditure on their development. However, they provide sufficient margin for smaller players to grow the market. This often results in significant profitability for larger players in the period immediately following the entry of the disruptive solution into the market. In the long run, this profitability is gradually wiped out as the smaller players *grow the market bottom-up*

3.2. The bicycle gear system as a modular innovation

Modularity is the process of dividing systems into sub-systems that are interdependent yet independent. Product modularity involves features such as separateness (Schilling, 2000), i.e., the extent to which a product can be disassembled and recombined into a new product without the loss of functionality; specificity, i.e., the extent to which there is a clear, unique, and definite product function with system interfaces (K. Ulrich, 1995), and transferability (Starr, 1965, 2010), i.e., the extent to which the product can be used in other systems (Mikkola, 2006). Therefore, there are degrees of modularity depending on the interconnectedness of modules both across and within the system, and the design choice is mediated by the level of acceptable complexity. Baldwin and Clark conducted a longitudinal study of the computer industry (Baldwin and Clark, 2000) and characterized modularity as the ability to increase the manageable complexity of a desired solution by limiting the scope of interaction between modules, and by allowing parts of a system to be worked upon individually without modifying the entire system. Lower complexity allows greater experimentation and distributed improvements across modules lead to improved system reconfiguration, thereby accelerating product innovation.

The six modular operators suggested by Baldwin and Clark (2000) are:

1. *Splitting* a system into two or more modules
2. *Substituting* one design module for another
3. *Augmenting* to add a new module to a system
4. *Excluding* a module from the system
5. *Inverting* to create new design rules
6. *Porting* a module to another system

The bicycle, a 15th century idea that is traceable back to Leonardo Da Vinci, is a modular product (Galvin and Morkel, 2001; Randall and Ulrich, 2001; K. T. Ulrich and Ellison, 2009). We focus on the 'gear--system'- a module, that was extensively studied by Fixon and Park (2008). Gears are based on the principle of relative motion between the pedal and the wheel, and were invented to achieve better cadence, i.e., greater wheel distance with lesser pedaling effort. Cadence (or pedaling rate) is a measure of the performance of the gear system. The 150+ year development timeline for this modular innovation is captured in Tables S–1 in the supplementary material.

Inventors have integrated the gear system into the bicycle by strengthening the interdependence between the interacting modules. While initially interdependent, subsequent improvements were independently pursued. This is a characteristic of modular innovations. The early development of the system up to 1975 focuses on *separation* of modules. The sequence of bicycle development from gearless with poor cadence to variable cadence enabled by precision shifting demonstrates Baldwin and Clark's observation regarding the ability of modular innovations to increase the system's range of manageable complexity. The subsequent development timeline also indicates the accelerated pace of improvement.

Importantly, as described by Galvin and Morkel (2001), most recreational and functional riders were contented with a standard gearless bicycle, yet much of the technological advancement was for the bicycle racing sport where thin victory margins and subsequent implications on bicyclists' careers drove the need for improvements.

Module *integration* between the 1980–1990's highlights the true essence of modular innovations. The Shimano 'Total Integration' was a

Table 3
The disruptive innovation archetype and associated simple rules.

Strategic component		Disruptive Innovation		
		Characteristic	Analyses necessary to yield rules	Simple rules
OBJECTIVE	*Vision*	A solution for a specific industry offering where underserved or overshot customers (low-end) or non-consumer (new market) segments are prevalent	- Study the needs of underserved or overshot customers (low-end) or non-consumers (new market)	- Provide a solution to an existing problem in a specific industry with just enough performance to satisfy the unmet needs of a niche customer (ignored by incumbents) with a goal to improve performance gradually so as to meet the needs of the average customer in the industry
	Relative performance goal	A lower performing product than average competitor offering on prevailing dimensions of performance. However, it also offers new benefits in new dimensions of performance	- Study performance of current market offerings - Identify prevailing performance dimensions where lower performance may be 'good enough' for some customers - Identify potential new performance dimensions	- Provide a new benefit to overcome a barrier to consumption faced by the target niche, which may often be associated with skill, wealth, access, time, behavior, attitude or belief
SCOPE	*Industry specificity*	A specific target industry	- Look for industries where unserved and/or overshot customers exists, and currently available offerings exceed sub-segment needs on some dimensions of performance	
	Customer segment	A niche customer segment, typically unimportant to incumbents.	- Study customers being served - Define boundaries of the market precisely - Look for unserved and/or overshot customers - Differentiate uninterested customers from those with compensatory behaviors via observation	- Start with overshot or non-served customer and move upward - Provide an improved means to satisfy or address existing compensatory behaviors
	Purpose-context	The unserved purposes-contexts of the non-customer	- Generate purposes and contexts of non-served customers - Conduct issue analysis - Answer 'why' they are non-customers? - Find out the barrier to their consumption-whether they are short on any of skill/wealth/access/time/behavior/attitude/belief - Map them and discover niche segments	- Target niche segments and their corresponding specific barriers to consumption
	Market capture channel	New and/or non-traditional market capture channels in order to grow undetected	- Understand channels exploited by current incumbents - Understand the channels that likely will reach the target niche customers	- Choose channel that incumbents are unlikely to pursue
	Investment/Risk	Lower risk investment	- Understand minimum necessary investment to achieve desired level of performance - Understand avenues for risk reduction	- Start small and reduce risk
	Price	Lower price than traditional market but at par with value provided. At par or higher price if new-market	- Study consumer willingness to pay - Study consumer willingness to pay for new performance dimensions - Study consumer value generated in new-market disruption, and consumer willingness to pay	- Recognize consumer value (quality) relative to context - Balance price and perceived value
ADVANTAGE	*Adoption challenge*	`Good enough' for targeted customers, but can be initially perceived as lower quality, thereby causing eventual adoption issues while moving up-market	- Study market perception phenomena for prospective customers	- Demonstrate the effectiveness of offering to targeted niche customers
	Effect on customer perception of performance	Can change the importance of performance dimensions for certain customers. May lead to customers' appreciation of traditionally unrealized performance dimensions	- Study compensatory behaviors	- Make customers realize their compensatory behaviors and demonstrate how the solution eliminates the need for those behaviors
	Ability of the offering to solve more complex problems	Does not enable the capture of more complexity of the customers' purpose-context	- Build a perspective on the various levels of complexity of customers' purpose-contexts	- Ignore desire for more complexity of solution - Focus on targeted delivery of selected benefits
	Basis of competition	Shifts the basis of competition by introducing previously unavailable performance dimensions	- Understand competitors' differentiation strategy	- Do not compete directly with incumbents for as long as possible - Compete on a different performance dimension
FLAWS	*Potential strategic flaws*	Listening only to the voice of the customer and the most lucrative customer segment; Performing market segmentation at a lower resolution than required; Making investment decisions guided by sunk costs; Focusing only on core competencies	- Analyze customer segmentation for over or under focus - Analyze investment decision drivers and decision maker tendencies - Analyze over or under focus on core competencies	- Listen to non-customers and overshot customers - Employ purpose context mapping to define market segmentation - Do not prioritize marginal profitability over building new capacity

(*continued on next page*)

Table 3 (*continued*)

Strategic component	Disruptive Innovation		
	Characteristic	Analyses necessary to yield rules	Simple rules
			- Do not let core competencies become a barrier to subsequent innovation opportunities

major improvement in *user centric design,* enabling gear shifting without lifting the hands off the handlebar, which was significant to *athletes' safety*. *Precision* and *safety* provided by an integrated system were more valuable than the *flexibility* of the modular system. Hence, although integration reduced the overall modularity of the gear system, it improved the performance of the overall bicycle system by further increasing the range of manageable complexity. In contrast to traditional views on modularity, an integrator (Shimano) became the dominant player in the industry (Fixson and Park, 2008). This highlights the interchanging hierarchical relationship between separation and integration in modular innovations that strategists must recognize. Separation enables focused and rapid advancements up to a point, after which integration becomes relatively more valuable.

Over the 2006–2015 decade, integration further increased the range of manageable complexity with the introduction of electrical shifting and the gradual removal of all design constraints of cables such as holes, holders, nuts and other parts that supported the cable system. Furthermore, SRAM's eTap model eliminated the decades old design norm of having front and rear shifters on either side of the bar. It simplified the configuration to just one paddle on each side, with the right side shifting to higher gears and the left side to lower gears, thereby inducing more simplicity to gear shifting and further improving safety. These above observations are illustrative of the *inverting* modularity operator explained by Baldwin and Clark, which lead to increased design possibilities. Independence from cables meant that the gear system module could be *retrofitted* (or in Baldwin and Clark's terms – *ported*) onto any type of road bike. This made the bicycle's drivetrain highly backward-compatible, further increasing manageable complexity. Lastly, the wireless protocol in modern bicycles allows for real time data collection and paves the way towards an IoT future by creating a feedback mechanism for further improvement. This is a new dimension of performance heretofore unavailable to customers.

3.2.1. *Viewing the bicycle modular innovation through the strategy framework*

Bicycle innovations manifested in the form of improvements either along accepted dimensions of performance or by introducing new performance dimensions at the *higher-end* of the market (professional sport). Innovations then *spilled over* to recreational and everyday customers. Hence, patents play an important role as a business tactic and govern product design. One case in point is that of the UNO group-born from the firm Rotor, which historically was a chainring manufacturer. In the age of *integration*, Rotor could not survive as a specialist manufacturer and had to vertically integrate. However, existing patents on energy transfer mechanisms did not allow it to use traditional modules of the drivetrain system. Out of necessity, they invented a hydraulics-based energy transfer mechanism in 2016, which became a substitute for the heavily patent-protected electronic derailleur module. This incident highlights a key characteristic of modular environments touched upon earlier, which is its *cyclical nature*. Thus, when standards are well-defined and modularity is sufficient, specialist players hold an advantage. However, as modularity increases so does complexity, and in order to gain control, integration of modules takes place. At this time, the advantage shifts to the integrator (Fixson and Park, 2008). However, over time, the integration is unable to sustain (perhaps due to constrained design choices or too much control) and modularity re-surfaces in the form of a bypass of the integrated sub-system or new standards. This cycle between modularity and integration is an important consideration for strategists interested in modular innovation.

The gear system evolution demonstrates how improvements in performance dimensions for the most demanding customers of the market are made possible due to modularity. In addition, modularity enables flexibility, which can support customization as per customer demand. Thus, the strategic intent for modular innovations requires *targeting a specific industry* with an objective to *enable customization* to *produce a higher performing offering* than the status-quo for the *most demanding customer segment, while also* leveraging flexibility to serve the *average customer's* purpose-contexts.

For the most-demanding customers, building *communities* leads to a ready market as they double-up as early adopters. Thus, a strategy should include innovating close to a target customer and spillover to the mass market with relative innovation costs supported by premium pricing that most-demanding customers are willing to pay. The *purposes-contexts* (A. Sheth and Sinfield, 2021) of the most demanding customers should be identified. Recreational bicyclists should not be the target customer for modular innovations as they are likely to be overshot on several performance dimensions and likely to find the higher price point unjustified. Additionally, modularity aids in achieving the higher performing innovations by facilitating disjointed development and rapid iteration once interface designs are standardized (Lau et al., 2011). Conversely, modular innovations are high-risk due to interdependencies and not necessarily low investment. Therefore, having too many modules is detrimental to innovation (Lau et al., 2011). Most importantly, module integration increases control but necessitates caution on the part of strategists due to the reduction in module interdependence and reduced flexibility.

Today, all bicycle racing teams are part of 'groups' led by major module manufacturers and system integrators. This speaks to the impact potential of modular innovations on industries and its strategic significance. Table 4 provides the characteristics of the modular innovation archetype and draws out the analyses steps and simple rules.

3.3. *The optical fiber as an enabling innovation*

Innovation outcomes impact individuals, groups, and even societies. Sinfield and Solis (Sinfield and Solis, 2016; Solis and Sinfield, 2015; Solis Novelo, 2015) create an impact-based taxonomy of innovations, and introduce enabling innovations as those that exploit a fundamentally new paradigm and promise the 'enablement' of high impact in terms of their reach, significance, longevity and paradigm change. The impact manifests in the form of a cascade of new (progressive) innovations that stem from the enabling innovation, thereby regularly providing new and sustainable revenue streams for the organization in the future. Retracing historical enabling innovations reveals their dependence on key conceptual breakthroughs, often based on the scientific breakthrough of known barriers. This typically occurs over decades and is accompanied by inventions and discoveries (e.g., the development of the transistor). Once conceptual barriers are overcome, the subsequent time period is named the 'enabling window' and is characterized by the invention of generational enablers. These advances (conceptual and/or technical) converge to tip the paradigm, giving rise to the enabling innovation. This stage is followed by a cascade of progressive innovations that drive impact. Each stage has specific characteristics providing clues for organizational strategists to manage it. The optical fiber is one such enabling innovation that changed society. Below we illustrate the enabling innovation life-cycle for the optical fiber from Corning Inc.,

Table 4
The modular innovation archetype and associated simple rules.

Strategic component		Modular Innovation		
		Characteristic	Analyses necessary to yield rules	Simple rules
OBJECTIVE	*Vision*	A solution for a high-complexity systems where opportunities for independent module development exist	- Identify system interfaces where modularization is possible and beneficial - Study the purpose-contexts of current and new customers	- Develop integrated solutions composed of interdependent yet independent modules that enable greater range of manageable complexity and address key purpose-contexts of current customers or new-customers
	Relative performance goal	A higher performing product than average competitor offering in area of modular development	- Study performance of current market offerings - Look for areas where performance can be improved	- Build highest performance solution - Build highly customizable solution
SCOPE	*Industry specificity*	A specific target industry	- Look for industries where the currently served customers are demanding more. - Look for industries where customer offering complexity is not captured by current offerings	
	Customer segment	The currently served customer segment as well as non-served customers	- Study customers being served - Look for performance seeking customers - Look for customized solution seeking customers	- Create a community of performance seekers and capture them via integration - Create a highly customizable offering and serve a larger base
	Purpose-context	The served as well as unserved purpose-contexts of customers	- Conduct issue analysis - Generate purposes and contexts of served but dissatisfied customers - map them and discover performance improvement niches	- Target most-demanding customers - Target flexibility seeking customers
	Market capture channel	Channels that group high-performance seekers into a community and/or non-traditional channels that enhance customized purchasing	- Start with premium customers - Trickle down to average customers - Ignore least profitable customers	- Start from the most demanding customers and move toward the average
	Investment/Risk	Not necessarily low investment but high risk due to interdependencies	- Identify design opportunities to reduce modular dependencies - Identify risk reduction opportunities	- Focus on approaches that reduce modular interdependence but improve performance to reduce risk
	Price	Higher price than most currently available solutions	- Analyze the value to most-demanding customers - Analyze the willingness to pay for customized offerings	- Sell at a premium for high-complexity offering - Sell at premium for customized offering
ADVANTAGE	*Adoption challenge*	Might be perceived initially as a large change for the average customer thereby leading to apprehension	- Study the market perception phenomena for prospective customers - Study the purchasing behaviors of the most-demanding and the average customer	- Demonstrate the performance to most-demanding customers - Demonstrate the flexibility of offering to the average customer
	Effect on customer perception of performance	May lead to customers' appreciation of traditionally unrealized performance dimensions	- Study purpose-contexts for customers' desired but unrealized performance needs	- Add new dimensions of performance via combination of modules - Add new dimensions of performance that customers are desiring
	Ability of the offering to solve more complex problems	Enables capture of more complexity of the customers' purpose-context	- Look for complex solutions whose achievement is simplified by modularity - Look for integrated modules which can be re-modularized to offer superior solutions	- Identify the cyclical phase of integration – separation and its ability to increase range of manageable complexity
	Basis of competition	Shifts the basis of competition by capturing more technical complexity via modularity and captures value-chain segments via integration. Integration is often needed to make a significant leap. Once an architecture is adopted, i.e., standards are created, modularity can begin again.	- Look for complex modules whose integration can lead to greater control over variables and therefore, a leap in performance	- Complete by controlling key modules of the solution and protect them - Compete for best-in-class status - Complete for greatest customization status
FLAWS	*Potential strategic flaws*	Creating too much modularity can increase complexity rather than decreasing it, thereby integrating modules but not improving performance significantly	- Identify the number of manageable modules - Identify the number of necessary modules - Identify interfaces for integration and separation - Analyze for over integration or over separation and for integration-separation imbalances	- Maintain a balanced integration-separation cycle - Reduce the number of modules - Reduce integration and set standards for module interface management

that allowed them to thrive in a commoditized glass-making industry, and dominate the optical-communication transmission line space.

Corning Inc. has been at the cutting-edge of research and development in glass technology for more than 100 years. It dates back to the 1870s as a glass supplier for Thomas Edison's bulb. Since then, Corning has ventured into glass-derivatives and composites such as glass-ceramics and silicone-glass. To understand the company and its enabling innovation, one first needs to understand the physics and chemistry behind glass making. In contrast to intuition, glass is an amorphous solid, i.e., its molecular structure is not regular. The lack of crystallinity frees it from the stoichiometric requirements of crystalline solids (Mauro, 2014), implying that the properties of glass are a function of two fundamental factors-its chemical composition and its handling process at high temperatures (~> 1000 K). Glass composition can be a combination of several chemical combinations but scalability of the manufacturing process is key.

Glass use was increasing in the early 1900's but its durability was an issue as glass shattered easily with temperature variation. Corning successfully reproduced a known breakthrough in glass making technology-*borosilicate glass*-through experimentation with new chemical compositions and high temperature processes. This resulted in a low-thermal expansion heat resistant glass that was used in lanterns, and in cookware applications such as baking. Corning's ability to scale the production of borosilicate glass led it to dominate the market and become a major research center. Over the next 70 years, Corning developed *low-attenuation optical fiber*, an enabling technology that impacts modern life. The optical fiber and the diode LASER (a separate enabling innovation developed outside Corning) have enabled the development of numerous long-range optical-communication technologies in use today that serve as the backbone of the internet! Additionally, many progressive innovations such as some forms of laser manufacturing, laser medicine, and lighting solutions are dependent on fiber optic cables for laser-light delivery, thereby reiterating the high-impact nature of enabling innovations.

Enabling innovations depend on key conceptual breakthroughs. Besides its ability to produce borosilicate glass at scale, Corning's innovation in glass *fire polishing* to remove persistant contaminants was crucial. It relied on its 30+ years of knowledge and experience producing low-impurity high-clarity fused-silica glass to develop a key breakthrough between 1966 and 1972- *ultra-clear glass*. Whereas the fused-silica approach was out of favor among the larger research community due to issues such as low refractive index and high melting temperature requirements, Corning went against general belief and selected fused-silica as the material for the optical fiber core. The choice of fused silica as the cable core was premised on Corning's proprietary process-*flame hydrolysis*,[1] which allowed the production of pure silica at scale (Hecht, 2004). Hence, flame hydrolysis is a key processual breakthrough necessary for the production of ultra-clear glass, which is a critical component of optical glass fibers. It is important to note that technological breakthroughs might occur as a solution to a different problem and/or in a different temporal frame. For instance, the intention of the effort that led to flame hydrolysis was to actually develop low thermal expansion glass (and not clear glass). Low thermal explansion glass was interesting to Corning in the 1930s as Corning was an established company in that category with its PYREX range of cookware glass. With similar motivation, another scientist at Corning discovered that adding titanium dioxide to fused silica would reduce its thermal expansion to zero at room temperature. Later Corning established a separate business that built and sold large pieces of *ULE (ultra-low expansion) glass* for telescope mirrors and spy satellites. It later also used the same in 'Corningware' ceramics. In combination, the titanium doped silica was the core and the fused silica was the cladding for the eventual single-mode optical fiber that Corning produced. However, achieving this required another process breakthrough, which was the *vapor deposition process* for the glass fiber preform that scientists at Corning had successfully developed in the late 1960s. These standalone breakthroughs collectively allowed for the development of the *low-attenuation* (~16 dB per kilometer) *single mode optical fiber,* which was an enabling innovation for fiber-optic telecommunications (Hecht, 2004). The enabling innovation has led to a massive cascade of progressive innovations in information communication and beyond.

The aforementioned technologies are protected trade secrets and sources of continuous revenue even today. However, they undoubtedly have a reach beyond Corning, ushering in the age of information! Tables S–2 in supplementary material traces Corning's enabling innovation.

3.3.1. *Viewing the optical fiber enabling innovation through the strategy framework*

Enabling innovations typically have lengthy development-cycles (~70 years in this case), necessitating a long-term strategic view. Despite this long cycle, focusing on the enabling window is most critical as decisions made during the enabling window shape the overall innovation S-curve. With this focus, the strategic intent leverages knowledge from prior conceptual breakthroughs to develop high-impact innovations for the future. For the optical fiber, the decisions to select the fused-silica approach for the low expansion inner core and the development of the vapor deposition process for the uniform deposition of the titanium doped glass as the outer cladding were key generational enablers. Although seemingly 'by design' in hindsight, each decision was taken under uncertainty about the long-term outcome. However, they were rationalized for the short-term. This is perhaps the most important point for strategists focused on the enabling window. Enabling innovations require large investment and are very likely to get shelved, unless their development strategy includes short-term rationalization plans. Thus, pursuing a low-risk path toward the enabling innovation is a favorable strategy (Sinfield and Solis, 2016). This is done by using a lily pad approach, where a company leaps across markets by pursuing initial applications that are each short-term rationalized yet cumulatively supportive of the long-term vision. Essentially, lily pads help justify the expenses incurred in the short-term by paying for themselves, either literally or through learning, while simultaneously allowing for the development of the pieces critical to the long-term enabling innovation. Lily pad applications may be found within the focal industry or in another industry outside it, and thus, the strategic focus must often extend beyond the organization's core industry to encompass multiple customer segments in multiple markets. Studying potential customers' purposes-contexts systematically helps identify lily pad opportunities (A. Sheth and Sinfield, 2021). Interestingly, customer needs might not be apparent to customers themselves due to set-in compensatory behaviors. This can be countered by illustrating the benefits of the innovation and is often necessary. Additionally, a key step is to evaluate the lily pad offering against the status-quo solution and measure the performance improvements generated by the lily pad, i.e., quantifying the 'available headroom' for performance improvement. Generally, large headroom justifies lily pad development, whereas little headroom prompts alternative search. The strategic intent should be focused on the technology's survival through the enabling window and this should be recognized when pricing the lily pad offering. The enabling innovation itself, once developed and protected (e.g., by patents), could ultimately garner a premium. Risk reduction strategies such as collaborations need careful management as trade secrets and intellectual property are the basis of competition in enabling innovations.

[1] Previously, in the 1930's, while tackling another issue, organic chemist – Frank Hyde-discovered that silicon tetrachloride boiled at a little higher than room temperature. He sprayed it on an oxy-hydrogen torch to discover that the hot water in the flame reacted with the silicon tetrachloride to yield a fine dust of the purest silica anyone had ever made. This was developed into a process called flame hydrolysis, which is still used today to develop materials of exceptional purity.

Once the enabling innovation is developed, a new market identification process must ensue for progressive innovations. The search space should include complex problems, even those previously deemed intractable (Sinfield et al., 2020), where the enabling innovation could provide solutions. The post-enabling innovation stage is marked by a cascade of high-impact progressive innovations. They are called such because they innovate in the newly established paradigm and help progress it rapidly. It is apparent that the enabling innovation archetype is distinct in its strategic intent from the previous two archetypes. Table 5 summarizes the enabling innovation archetype and draws out simple rules for its pursuit.

4. Discussion

The case studies in Section 3 demonstrates application of the strategy framework in organizing strategic decisions associated with three innovation cases and conducts a cross-comparison along common choice dimensions, effectively linking three seemingly disparate innovations analytically. This is valuable but non existent in the current discourse on strategy or innovation. Its value is primarily driven by the ability to examine choices through different viewing lenses.

The first lens is that of context. We know from the literature that a strategy is highly idiosyncratic and context dependent. Thus, the framework would fail if it were unable to capture the nuances of a

Table 5
The enabling innovation archetype and associated simple rules.

Strategic component		Enabling Innovation		
		Characteristic	Analyses necessary to yield rules	Simple rules
OBJECTIVE	*Vision*	A solution for long-term, high-impact, and novel growth, premised on achieving known technical breakthroughs and surviving through the development cycle	- Identify technical challenges that are promising in theory but need resources (e.g., time, money, effort, and talent) to come to fruition - Identify technical challenges that have headroom but are not in serious development due to resource requirements	Create a high-impact solution to enable a cascade of progressive innovations. In process, develop lily pads that help the enabling innovation survive the enabling window
	Relative performance goal	Higher performing products than average competitor offerings leveraging the technical breakthrough	- Study performance of current market offerings - Look for areas where performance can be improved	- Build higher performance portfolio offerings leveraging the technical breakthrough
SCOPE	*Industry specificity*	Applications beyond the industry of origin are often necessary. These are known as lily pads	- Evaluate lily pads for available headroom, i.e., how much improvement to the current solution is viable and is it worth it?	- Search within and across industries for self-paying lily pads that have benefit potential for the enabling innovation - Locate the ideal customer segments across multiple industries whose purpose-contexts align with lily pad offerings
	Customer segment *Purpose-context*	Multiple customers in multiple industries Multiple served as well as unserved purpose-contexts of multiple customers in multiple industries	- Conduct issue analysis - Generate purposes and conexts of customers in base industry - Map them and discover lily pads in industry of origin - Conduct industry analysis - Generate purposes and contexts of customers in related industries - Conduct headroom analysis - Map them and discover lily pads in industries outside industry of origin	
	Market capture channel	Typically begins with customers in need of enabling technology for their innovations. The need might not be apparent to them	- Isolate customer segments that have an unmet need or compensatory behaviors and can benefit from the lily pad offerings	- Use lily pads to survive through the enabling window - Use lily pads as market makers
	Investment/Risk	A high investment high risk proposition unless de-risked via lily pad offerings	- Analyze high risk factors	- Invest in pursuing non-standard paths to achieve breakthroughs - Collaborate to reduce risks
	Price	Higher price than most available solutions	- Benchmark competition price and offering quality	- Sell at prices above costs but typically not at premium during enabling window - Once established, charge premium if in line with strategic intent
ADVANTAGE	*Adoption challenge*	Can be initially perceived as too much of a change for the average customer, thereby leading to apprehension in creators of progressive innovations	- Identify long standing pressure points for customers - Identify customers' key risks	- Focus on demonstrating future high-impact potential - Focus on underlining eventual potential shifts in basis of competition - Exploit customers' 'fear of missing out'
	Effect on customer perception of performance	Creates a new improved set of performance expectations	- Measure customers' change in perceptions via analytical tools	- Help customers realize new dimensions of performance that are enabled
	Ability of the offering to solve more complex problems	Enables capture of more complexity of the customers' purpose-context	- Map purpose-contexts to level of solution complexity needed to achieve them	- Look for solutions that are typically considered complex but whose achievement is enabled by the enabling innovation
	Basis of competition	Shifts the bases of competition	- Analyze what wins in the current market	- Compete to shift the dominant paradigm - Compete through intellectual property and/or trade secret
FLAWS	*Potential strategic flaws*	A poor vision for long-term agglomeration of innovations that will be enabling and a narrow exploration of potential lily pads	- Iteratively re-visit the overall vision and seek out revision opportunities - Quantify lily pad benefits (e.g., money, new customer acquisitions, market learning and entry)	- Operate at the first principles level of the enabling innovation - Maximize the generated lily pad value

particular innovation form. As demonstrated above, the case descriptions along with the corresponding tables successfully capture the nuance of context for each form, thereby facilitating a comparison of the 'when' and 'where' aspects of a strategy. The three innovations are distinct in their developmental durations, yet can be captured and compared. While the **vision** for a disruption strategy is to serve those facing barriers to consumption with an offering tailored to their unique context, that for a modular strategy context is to address high-complexity systems where opportunities for independent module development exist, and that for an enabling strategy is to enable a cascade of progressive innovations through risk-mitigated investment. Similarly for sought product **performance dimensions**; while disruption strategy focuses on lower performance on traditional dimensions and adding benefits on new dimensions, modularity focuses on a higher performing product than the average competitor offering, and the enabling strategy seeks out state-of-the-art performance on new dimensions. Similarly for the **choice of market**; the disruptive strategy (initially) focuses on niche customers in core sectors, modular strategy focuses on the most-demanding and customization-valuing segments, and enabling strategy focuses on both core and non-core customers in multiple sectors. Strategic choices in other components also vary considerably across the three innovations, i.e., the scope, advantages, and flaws. In each case, the construct captures the strategic logic and enables comparison across the action components of the strategies. Furthermore, for each case, all components of the strategy must fall in place correctly for that archetypal innovation to ensue. Thus, the framework captures strategic choices, which collectively imply a necessary and sufficient conditionality to make a disruptive innovation disruptive, a modular innovation modular, and an enabling innovation enabling.

The second lens is that of strategic choice dimensions, which is valuable because strategic decision making is the domain of managerial choice and a dynamic capability. Each strategy is adequately captured using the choices along the 'objective', 'scope', 'advantages', and 'flaws' top-level structure. Further, the components of each top level grouping speak to a specific detail that is further useful in differentiating along individual components. Granularity at the strategic component level ensures differentiation among strategies that might be challenging to produce without the framework. Additionally, it provides a method to create degrees of variation between strategies. A fine analysis of strategic differences can capture the degree of differentiation between strategies, and determine if the differences are more or less prominent along specific dimensions.

The choice lens is individually valuable. That is to say if contextual descriptions were removed from the case, the strategy framework would itself lead to a sufficiently complete strategy for an innovation. Three cases are perhaps not enough to claim generalizability or completeness of the framework. However, it is an opportunity for future improvement to use the strategy framework to explain new innovation archetypes and further test it. Doing so would either lead to reconfirmation of its validity or the discovery of new choice dimensions as additions to it. This is a promising path for future research in the field.

The third lens is that of the strategic logic, i.e., linking context and choice to a goal. In standalone discussions in strategy, the goal is either presumed as broad competitive advantage or not specified across choice dimensions. However, the proposed framework breaks down each choice dimension along the goal and facilitates a more nuanced view of 'why' a choice is pertinent. For instance, the strategic choices in developing the optical fiber are completely explained using the 'leverage' logic. Although the development lifecycle spanned decades, the enabling innovation targeted the development of a capital intensive core-knowledge-based technology in the moderately dynamic information communication technology market. The company focused on building both core and non-core resources that enabled relative performance improvements over time. Core resources effectively changed the basis of competition due to process trade secrets and intellectual property that were then well-leveraged and premium priced in the optical fiber manufacturing market. The innovation found general applications beyond an industry and customer. Similarly, Uber's strategic choices are fully explained by the position logic. However, it is plausible that an innovation strategy is not fully explained by a single strategic logic. This cannot be ruled out and highlights a possibility that a complete innovation strategy might be composed of more than a single logic. This reinforces our theoretical understanding of strategy being a highly nuanced and idiosyncratic construct. It also creates the possibility of future research where innovation strategies can be verified across choice dimensions for the underlying logic and could plausibly yield new strategic logics.

The literature proposes that innovation is enabled by dynamic capabilities residing in 5 distinct types of managerial levers (1. Mission, goals, and strategy; 2. Structure and systems; 3. Resource allocation; 4. Organizational learning and knowledge management; and 5. Organizational culture) (Crossan and Apaydin, 2010). An explicit innovation strategy (Miller and Friesen, 1982) is a primary managerial lever to match innovation goals with the strategic objectives of the firm (Tipping et al., 1995). Thus, choice making is inherent to innovation strategy. However, proactivity in innovation strategy is not guaranteed. The strategy framework successfully demonstrates this in the tables for the three innovation forms. In addition to explaining the 'when' and 'why', the strategy framework enables a flipped view of the strategy and delivers the 'what' and 'how'. This enables proactive innovation strategy and innovation management for specific goals, which is an important objective for both theory and practice.

The derived simple rules are in the form of 'do this' when the appropriate generalized context is detected. However, it would be inadequate to simply employ the framework. Instead, when a new situation is encountered, a strategist should decontextualize it to observe its core structure subsequently mapped to a fitting pattern, and then apply the appropriate simple rules back in a manner that accounts for context specifics. Thus, the tailoring of strategic choices to contextual nuances, while keeping the underlying logic constant, is important. This can be done by using each framework component and the corresponding lines of enquiry. Tailoring entails making assumptions and rapidly testing them, which we argue is improved by the use of the strategy framework. Finally, the construct and simple rules collectively provide an inferred capability to strategists to proactively pursue specific innovation forms, provided appropriate technical and strategic contexts prevail. This proactive capability yields the firm a competitive advantage.

Lastly, the paper makes a direct contribution to the theory of strategic heuristics, which is built on the observation that practitioners make strategic choices using simple rules (heuristics) that are experientially learned. The theory reconciles an apparent contradiction-that strategy making is complex, yet strategic choices can be distilled into a set of simple rules (Bingham et al., 2007). Heuristics (simple rules) as decision-making devices have been explored across several disciplines including in Cognitive Science, where the focus is on biases (Tversky and Kahneman, 1974) and positive usefulness (speed and frugality) (Gigerenzer and Todd, 1999). In Management Science the focus has been on managerial learning (Bingham and Eisenhardt, 2011b; Bingham et al., 2007) and strategic decision making (Artinger et al., 2015; Bettis, 2017; Maitland and Sammartino, 2015). Hence, there is a strong basis to pursue the search for strategic heuristics, which in this case are devices to help us define, implement, and differentiate among innovation strategies. This paper enabled by the strategy framework demonstrates this for three specific innovation strategies, thereby contributing towards the emerging theory.

4.1. Opportunities for future research

The above discussion not only highlights the merits of the presented framework, but also highlights possibilities for numerous future

research avenues. Specifically, the framework can be further stress-tested with more innovation archetypes beyond the three chosen in this paper. Application to new cases may also highlight new contextual dimensions or strategic logics that could be added as framework components, thereby improving it. As a corollary, our work creates the foundation to allow researchers to 'engineer' new strategies and 'discover' new innovation archetypes by a reverse process of using the framework (built from patterns) to combinatorially create groups of strategic choices.

5. Conclusion

Innovation strategy is conceptualized as a set of context dependent and logically underpinned choices, which act as managerial levers to innovate in an industry. However, a construct to facilitate a consistent comparison of strategies is currently missing. In this paper, we develop a framework to enable strategic choice comparisons across four domains-objective, scope, advantage, and flaws. Strategic choice making is considered a dynamic capability, and we ground our logical arguments using the typology of strategic logics rooted in the resource-based view. We then invoke the literature on innovation archetypes and employ the framework to explain underlying strategic choices for the three archetypal innovations-disruptive, modular, and enabling. We discuss Uber as a disruptive innovation to the ground transportation industry, the bicycle gear system module as a modular innovation, and Corning Inc.'s fiber-optic cable as an enabling innovation to the information communication industry. We de-contextualize patterns and the logic in strategies associated with these innovation forms. In addition, we draw key questions that lead to simple rules, thereby demonstrating that we can extend our theoretical understanding of 'why a strategy' and 'in which contexts (when)' to address questions important for practical action, that is to say, 'what strategic choices' and 'how'.

The core issue is that strategic choices are contextual, idiosyncratic, and difficult to simplify due to complexity of circumstances. Therefore, exploring strategy as a hard science is challenging. Yet there is a need for a systematic approach to explore strategic decisions. The strategy framework is one step towards that systematicity, which provides an analytical tool to capture technical and commercial context dimensions that are driven by some strategic logic. Additionally, the framework has a second purpose in its practicality in facilitating proactive innovation strategy.

The first half of the paper develops the strategy framework that successfully locates regularities in the environment such that strategic patterns can be characterized. The top-level organizing structure is further resolved into its choice components, which are helpful in capturing nuanced strategy. The framework successfully links logic to generalized context to action (why-when-where-what-how) to characterize strategy and facilitate strategy comparisons. More importantly, it provides a device to generalize strategies by stripping away unnecessary contextual nuance and recognizing an underlying structure that drives successful actions in a given environment (external and internal). The second-half of the paper employs the framework to capture detailed strategic choices germane to three archetypal innovations from the innovation management literature. It is evident that the framework succesfully differentiates the objectives, scopes, advantages and flaws of the archetypes.

The primary contribution of this paper is the development of a construct to facilitate comparability of strategies, and to develop simple rules for innovation strategy, thereby advancing the discussion on the theory of strategic heuristics.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.technovation.2022.102534.

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