R&D Models for Advanced Development & Corporate Research

Understanding Six Models of Advanced R&D

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Abstract—Our purpose is to develop new models that define the advanced development & corporate research approaches of modern global high tech firms. While the world has moved on from Bell Labs' famous advanced research model, visionary and farsighted technology-driven innovation is still vital to many of today's most successful global technology companies. Corporate innovation strategies are implemented through research laboratories, academic collaborations, advanced technology groups, standards groups, CTO office prototypes, internal/ external incubations, and open innovations. Unlike the well-understood nature of short-term product development, long time frames, fuzzily defined goals, and unclear measures of success lead to uncertainty of how to best run and fund advanced technology and applied corporate research. While all firms agree that advanced research is vital, their measures and processes differ widely. To identify modern models of effective advanced research approaches, the context in which such approaches are most effective, and the metrics by which they should be evaluated, we interviewed leaders at various successful and established global firms such as Cisco, Intel, Google, and others. We used the data collected to inductively arrive at six models that characterize modern advanced research approaches. The approaches of these models were different in the sense that some rely on academic and industry collaboration while others revolve around disrupting the status quo. The fact that the companies included in this study were successful means that all the models reflect a useful approach to advanced research. Therefore, no single model should be considered as better or ideal than the other. The models could be of use to a company trying to create an appropriate advanced research approach based on its goals and needs. Similarly, these models could help a company fine tune its existing R&D approach as its goals and identity develop over time. The models we present here provide useful terminology and will serve as backbone for further study of advanced development & corporate research approaches.

Keywords—advanced development, corporate research, product and service development

I. INTRODUCTION

While the concepts of product and technology development have been studied for years and are well understood, limited information is available on the even more business crucial area of advanced development and applied corporate research. To gain insights, we analyzed data from a select group of global high-tech companies, based on a multi-step methodology and a series of in-person interviews. Our findings yielded six differentiated models whereby today's high-tech companies organize advanced development and corporate research. With these models in mind, any given firm can identify models currently in use and verify the balance of resources for the optimum benefit of the company.

Technology-driven innovation is integral in today's global high-tech companies. For most, innovation can be broken down into two categories:

1) Product or technology development.

2) Advanced development and applied corporate research.

Product development consists of well-studied processes. It focuses on developing a product from an existing platform. It is characterized by train schedule release cycles, product requirements, and a variety of checkpoints and funnels. The performance of technology development efforts can be measured using metrics such as market share, adoption, cycle time, and quality.

The metrics and best practices for advanced development and applied corporate research are not well understood. Companies agree that significant investment must be made to ensure new product introductions and upgrades, favorable customer image, skill retention, and other vital signs. Without advanced research, companies expect to face negative impacts on the bottom line. Furthermore, there is uncertainty about how best to measure the success of advanced research because its timescale can be quite long, its output can be hit or miss, and its connection to firm operations is not as apparent as that of short-term product development.

Companies differ in terms of their metrics and processes. Moreover, the environment has changed since Bell Labs set up the de facto model in the mid-1900s. Today's development time is much shorter and the relative necessary investment size is much smaller. Modern projects integrate pre-existing building blocks. They tend to leverage open source and open innovation concepts. Additionally, the current business environments focus on innovation culture leads to a better

understanding of how competitive firms can leverage advanced and open-ended work.

As it appears that no one approach to advanced research is the sole best one, the Center for Entrepreneurship & Technology, part of the UC Berkeley College of Engineering, commenced a two-phase study with the purpose of identifying classes or models of effective advanced research, the context in which they are most effective, and the metrics by which they should be evaluated.

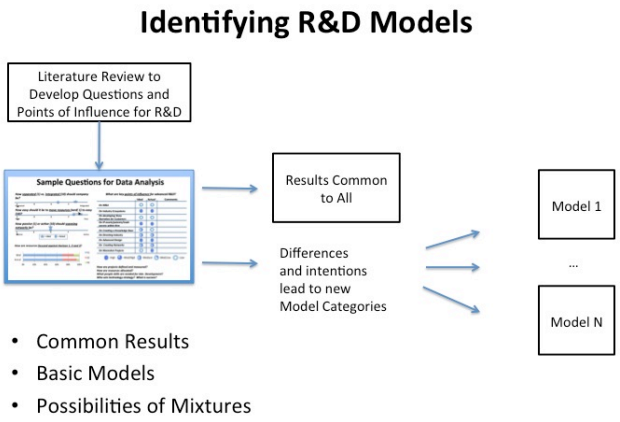
II. Background

Background work related to this topic falls into the following areas: First, there is a fundamental treatment of the innovation process, such as [Hansen and Birkinshaw], particularly for R&D. Related to these concepts are the strategic approaches to improving these processes and allocating resources within these innovation processes including horizon level planning [Carbone], [Managing Innovation, HBR], [Scinta, 2007], [Schwartz 2011], [Loch, 2000], [Ogawa, Susumu and Frank T. Pillar , 2006], [Brown 2002], and consulting based views of similar measurement topics such as [Deloitte and Thomas Reuters, 2010]. In addition, there is a body of work in general innovation strategy covering areas from disruption to open innovation that is more focused on the strategic questions of the business strategy, key resources, and innovation process, and in many cases illustrated by case example [Prahalad, 1990], [Christenson, 1997], [Huston 2006]. Very few of these works specifically focus on advanced development portions of R&D, however examples do include the well know case of Bell Labs [Wikimedia, 2014], and the Intel Case [MacCormack, 2003] which centers around the concept that projects should not be too predictable and should also not be too risky and also illustrates a line of thinking beyond roadmap driven planning.

III. Methodology

The methodology used to understand and categorize advanced development and corporate research approaches is summarized in Fig. 1. Secondary research took the form of literature review and focused on relevant articles and case studies. We used this review to inform and develop an interview questionnaire (primary research) and support and validate post-interview findings.

Fig. 1. Process to Identify Advanced R&D Models



The questionnaire included closed-ended scale questions, open ended questions, questions on current experience and perceived ideal experience in his/her particular type of company. Key questions were:

- How are projects defined and measured?
- How are resources allocated?
- What people skills are needed for Adv. Development?
- Who sets technology strategy?
- What is success?

We organized results into a series of dashboards to better understand and compare data (Fig. 2 and Fig. 3).

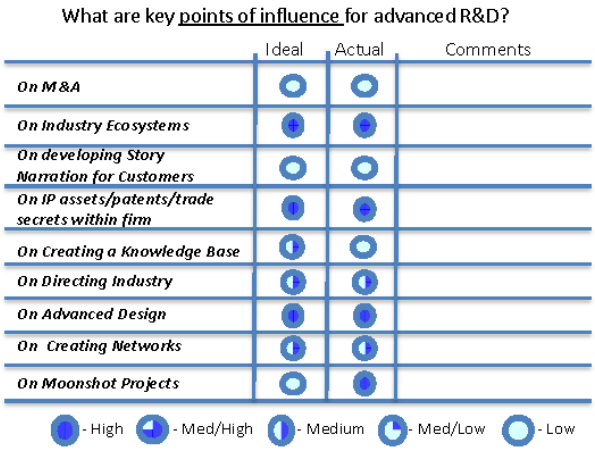


Fig. 2. Advanced R&D Sample Dashboard

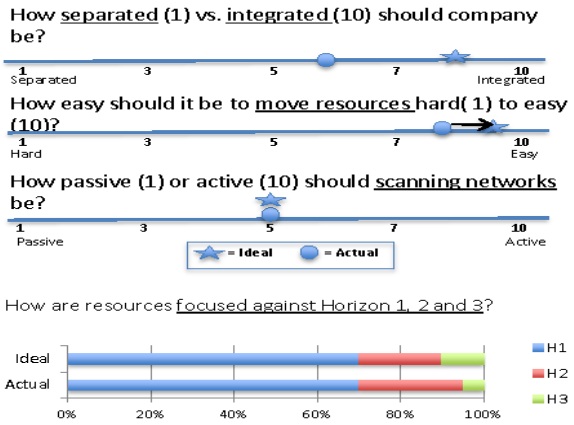


Fig. 3. Advanced R&D Sample Dashboard

We administered the questionnaire using in-person interviews with high-level managers from high technology companies headquartered in the US, Asia and Europe. We chose to interview companies that were large enough to have advanced research programs, represented a cross-section of high-tech and were commonly viewed as well-run firms. We had at least two interviews per company, with an initial sample including companies like Google, Samsung, VMware, Ericsson, Coca-cola, and Cisco. We further validated initial interview findings, reviewing our hypotheses against case studies and experience with companies like Intel. The interview responses were inductively used to identify the six different models of advanced development & corporate research.

IV. Common Findings

As each of the studied firms has exhibited long term success, it can be argued that any advanced development and corporate research approach that they all have in common could be key to their success. However, such common approaches could also be considered as artifacts of western business culture. Indeed, the common approaches turned out to be in line with widely accepted best practices. Therefore, we did not utilize them to develop the six models.

1) Horizon-Level planning is a common model and illustrates that firms operate in parallel as they pursue projects of different timescales and projects that require different amounts of external learning. H1 projects typically do not require significant external learning. However, H2 and H3 projects require firm level learning of new technology, new markets, and new paradigms. Furthermore, all firms believe in similar Horizon-Level allocations:

- H1 Core Business: 60-70%,
- H2 Adjacencies: 20-30%
- H3 New Categories: 5-10%

2) All firms believe that soft skills, innovation culture, and hiring practices are key ingredients of advanced development and corporate research approaches.

3) With regard to university networks, all firms believe that both sensing (listening) and active (directing) are equally important. This implies that it is normal for the same firm to fund some projects where they simply participate and listen to external institutions such as universities or other thought-leadership works. In other cases, however, separate projects are funded where the interest of the firm directs the external advanced work that is being funded.

V. The Six Observed Models of Advanced R&D

A. *Model 1: Roadmap Driven*

Roadmap driven research work is the most fundamental, safest, and most predictable category of advanced work. In this model, a company looks ahead in its current roadmap and starts advanced design of its next generation. For example, Intel may set a target for its next processor or a router firm may set the performance target of its next speed of routing backplane. The emphasis here is typically the advanced design itself and the IP generated. Successful projects meet the deadline, result in the enhancement of the product, and achieve better performance and other key purchase criteria.

Characteristics	Focus on IP and Advanced Design of H1 Areas
Budgeting/ Prioritization	Business units own/manage budgets
Metrics/ Success Measures	Measures: Number of Patents, Adoption in Next Product, Performance/ Differentiation

Table 1: *Roadmap Driven*

B. *Model 2: Transition Look Ahead*

The next step in evolution of advanced work is generally centered on the opportunities and concerns that the next market transition or product line might not be on the company's current roadmap. And if such a deviation is to happen, advanced research groups that focus on these issues start to investigate independent areas for investigation. In these cases, the development of "customer narratives" and "what is next in the industry" start to become more important than the design itself. A measurable success may include an article in a business week magazine. Other influence factors such as standards, body leadership, and industry leadership become more relevant. For example, Ericsson develops its advanced technologies in tandem with the relevant standards' progress. This creates the advantage of being ready with the product at the same time as the standard is ready. This also influences the standard towards Ericsson customers' narrative and Ericsson's technology strengths. This model focuses less on the next stage of a business unit product line and more independently on the off-roadmap directions that could be opportunities or threats. The Transition Look Ahead model maintains existing success in core business by channeling the progression of external market. A measurable success may include an article in the Business Week magazine or Forbes. Such an article enables a company to alter its customers' narrative.

Characteristics	Focus on Customer Story Narration, Standards, Demonstrating Industry Leadership and push to

	H2
Budgeting/ Prioritization	Adv. R&D uses central budget. Adv. R&D sets own direction with signals from CTO, Bus, and many external sources. Quarterly review cycle, central CTO coordinates with BUs CTOs
Metrics/ Success Measures	Measures: Standards body influence, Number of customer meetings and public (business) articles. External awareness, customer perception of technical leadership, and awareness of market transitions.

Table 2: *Transition Look Ahead*

C. Model 3: Fully Integrated R&D

This is a model used in "product-centric" firms like Google and Apple. Individual groups tend to have a great deal of freedom. Additionally, each R&D group must have its own portfolio of product deliverable projects as well as longer-range experimental projects. It is understood that at least some of the more experimental projects must fail or the group is not pushing itself hard enough. Experimental projects are often feature capabilities that competitors do not have or have not thought about and as such, they are not considered as catch-up projects. IP, Advanced Design, and moonshots are all relevant to this type of advanced research structure. The success of this type of advanced research approach can be measure in four ways:

1) Failure of some projects.

2) People being amazed by the outcome of a project

(say "wow, we didn't know that was possible").

3) Absence of complaints.

4) Lack of competitors

Characteristics	H1, H2, and even some H3 within each R&D group. Focus on IP, Advanced Design, and some Moonshots.
Budgeting/ Prioritization	Central CTO and executives set R&D budgets. R&D Groups have lots of freedom. Mix of low risk with high risk projects within each group.
Metrics/ Success Measures	Measures: Adoption in Next Product, Demonstrate competitive differentiation, Number of Patents. "Wow", we did not know that was possible. Some projects must fail.

Table 3: *Fully Integrated R&D*

D. Model 4: Full-on Corporate Research

This is a model for research and development that is intended to be quite separate activity for advanced technology. Google and other companies also have groups that follow this philosophy. The logic behind these projects is that if product groups could possibly do it, then research teams should stay away from such a project. However, for these types of projects (like Google Glass or Self-driving Cars), a company completes paradigm change for the firm, the industry, and society. These firms tend to say, "If you cannot afford to do this type of work, then do not do it at all." Influence points for this model on the firm tend to be IP, advanced design, and moonshot projects. Success can be measured by a ten-fold impact. This is the true moonshot project/mentality. Failure is entirely expected since only a small percentage of these projects become successful. This is the ultimate "wow" effect. This model can only be followed by a company that can afford to implement it without straining its budget, the budget's allocated centrally, and the decision maker is the CTO or CEO. This model is unusual because it genuinely expects failure 90% of the time (this apparently vastly accelerates researchers' ability to hit on a very great, ten-fold success). This model can only be pursued when a company has excess capital.

Characteristics	IP Assets, External Industry Leadership, Moonshot. For industry leadership, H3 Focus.
Budgeting/ Prioritization	Complete independence. CEO / Central CTO with centrally allocated budgets. "If you cannot afford it, don't do it".
Metrics/ Success Measures	Projects have 10X game changing potential, Number of Patents, External awareness. Progress towards achievable game changers.

Table 4: *Full-on Corporate Research*

E. Model 5: M&A-Driven Advanced R&D and Open Models

This model relies heavily on investigating the external environment. This practice was most popularized by Cisco, a company that continues to develop its business with a high reliance on acquisitions. The CTO organization at Cisco also leads corporate development and the corresponding merger and acquisition activities. While the CTO develops a strong customer narrative, much work within the organization is to search externally for those firms that are at the beginning of a major market transition. This model is supplemented with Engineering Fellows that have lots of autonomy to create "skunk-works" within the firm as smaller centrally funded corporate technology development organizations. Skunk-works can lead to spin outs and spin-ins. To develop the new technology, small groups of trusted Fellow Engineers are given a small budget and form a "startup" in which they energetically develop the technology independent of the normal internal development activities. When the spin out has finished its work, it gets integrated back into the main company (Spin in). Critical activities include M&A as well as IP, External Industry Leadership, and Moonshot projects. Success using this model leads to increased market share and ease of entry into new markets. To effectively use this model, companies must be effective at acquisition, integration, and channeling new products into the market.

Characteristics	M&A focus with Market Transition Focus, IP Assets, Moonshots. Need strong channels and effective acquisition process
Budgeting/ Prioritization	CTO also leads Corp Development, BUs all have CTOs Centralized budgeting, influenced by Engineering Fellows (Skunkworks in BUs) Parallel Advanced Development (Corp) Spin-Ins.
Metrics/ Success Measures	Market share, Ease of entry in new markets. Number of Patents, Success/speed in acquisition integration.

Table 5: *M&A-Driven Advanced R&D and Open Models*

F. Model 6: Intrinsic Need-Driven Advanced R&D

This model is the farthest in terms of being both open-innovation oriented and progressive as a research organization. Quite often practiced by consumer firms like Coca-Cola or Proctor & Gamble, this model has a high focus on the intrinsic needs of customers and the society in general. On an annual basis, the firm develops at the top level a list of approximately ten intrinsic needs of its customers though market research. This list might include factors such as health concerns, desires, and interests in the environment. The advanced development groups use this list as a starting point for project identification that may lead to new products, product localization, IT advancements, and new packaging solutions. The idea is to reinforce the firm's global brand with products and features aligned to its intrinsic needs and societal benefits. Part of the logic for this model is usually to maintain a world citizen status as a company and to earn the right to maintain a leading global brand.

Characteristics	Brand driven and intrinsic need driven. For industry leadership IP Assets, Advanced Design, External Industry
Budgeting/ Prioritization	Yearly planning cycle rooted in intrinsic needs and focus groups with customers. Leads to product, package, and IT solutions.
Metrics/ Success Measures	Measures: Business Unit Adoption, Next Product, Performance/Differentiation, Effect on brand perception. IP or trade secret generation.

Table 6: *Intrinsic Need-Driven Advanced R&D*

The more interesting finding is that not all firms measure their advanced development projects in the same way due to differences in objectives and context of the firm's market position. Fig. 4 below shows where the six models fall on the spectrum of firm focus and firm "perceived" leadership, within an industry.

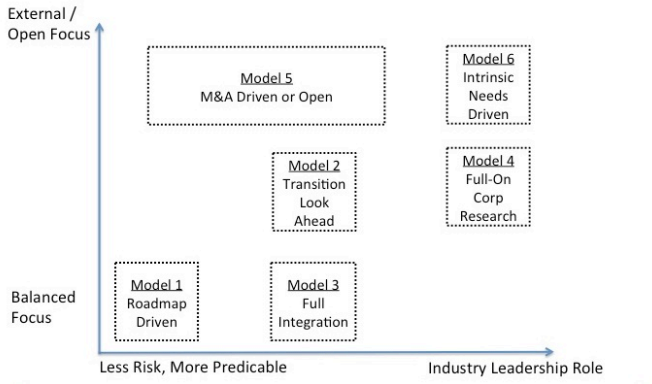


Fig. 4. A Positioning of Six Models of Advanced R&D

VI. DISCUSSION

Our work has identified useful terminology and models with which to characterize the advanced research approaches of various firms. Beyond their basic characteristics, we should focus on why any given firm may employ one or more of these approaches when examining these models.

No single model should be considered as the best or most ideal over the other. Since each of the companies studied is successful, all the models presented reflect a useful approach to advanced research. Thus, these models could be of use to a company trying to create an appropriate advanced research approach based on its goals and needs. Similarly, these models could help a company whose current advanced research approach is not successful.

By understanding the target allocation and target intentions of a particular approach to R&D, firms can decide how to ideally balance resources for the optimum benefit, aligning with the measures, organization, and budgeting models that best support those ideal allocations. It is however critical to note that the ideal resource allocation of a given company may change over time as the firm grows and/or moves into new areas.

Beyond the six models, the data makes clear that a firm's direction and R&D practices can be conceptualized into two groups:

1) The leading firms, who have no one to copy or compete with.

2) The pack competitors, who are fast followers with short cycle times.

While the leaders function with a target on their backs, constantly disrupting the status quo (and even their own status quo); the pack competitors must quickly jump on every successful bandwagon. The pack competitors leverage cost advantage by prioritizing the features developed by leading firms. The pack competitors do not gain an advantage by breaking the mold, but rather by fitting into the best existing molds as quickly and effectively as possible e.g. by using short cycle times. The leader invents tables, and the pack competitors invent faster, better ways of making cheaper and nicer tables. It is evident that certain models are most beneficial to a leading

firm, while others are most appropriate to a pack competitor firm. Firms can be both leaders and pack competitors in different arenas.

The process by which we arrived at the models was inductive. Each new interview provided additional information that was valuable in the entire research exercise. However, the concept of diminishing returns also applies. While interviewing additional leaders at other successful firms may lead to the development of another model or the refinement of one of the existing ones, more and more interviews will likely provide fewer and fewer insights.

It follows however, that the models we have presented may not be complete. There could still be other models to consider if we interviewed more firms. Regardless, our work provides a useful set of terms to distinguish one project type from another. This avoids lumping it all into one and helps firms articulate why they do these projects and what they hope to achieve, and what is ideal for their own circumstance or culture.

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