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Editor

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Introduction

Digital Technologies and Disruptive Innovation: From Processors to Platforms

Joe Tidd

There is no doubt that digital technologies have the potential for disruptive innovation in a wide range of sectors, both in manufacturing and services, and the commercial and social domains. However, popular commentaries on the potential of digital innovation to disrupt have suffered from two extreme positions: either, simplistic technological determinism, often promoted by technology vendors, claiming that the impending widespread automation of products and services will provide step-changes in productivity and new products and services; or, alternatively, very high-level broad discussions of business model innovation in traditional sectors. However, such arguments are not new, and similar claims were originally made for flexible programmable factory automation (Tidd, 1991), and later for digital service innovation (Tidd, 1994, 1995). However, the actual impacts have not been universal, and therefore, the outcomes of current digital technologies are likely to be highly-differentiated (Hull and Tidd, 2003; Tidd and Hull, 2006). More fundamentally, neither a narrow technological perspective nor a broad business view adequately captures the appropriate level of granularity necessary to understand the potential and challenges presented by digital innovation (Tidd and Bessant, 2018a).

Innovation concepts, models, and research provide greater insights into strategies for, and management of, digital innovation (Tidd and Bessant, 2018b). For example, the growing prominence of platforms and ecosystems in digital innovation, especially through enabling technologies such as Artificial Intelligence (AI) and the Internet of Things (IoT), reinforce the need to develop or acquire complementary assets to function and

capture value (Teece, 2018). Such complementary assets are central to the creation and delivery of value, by leveraging monetizing opportunities, for example: "Systems integrators, platforms, and multi-sided markets share what is sometimes referred to as a business ecosystem. For managers, the ecosystems perspective holds the promise of opening up the wider entrepreneurial and collaborative space that a new technology affords, and provides room for novel business models to succeed" (Baden-Fuller and Haefliger, 2013, p. 424). Therefore, the focus shifts from the potential for digitalization of products and services (Echterfeld and Gausmeier, 2018) to the creation of broader platform-based innovations (Inoue and Tsujimoto, 2018).

Platforms and product and service families are powerful ways for companies to recoup their high initial investments in technology by deploying the technology across numerous applications and markets. This strategy is not new or unique to digital innovation. Aircraft engine makers like Rolls-Royce and General Electric work with families of core designs which they stretch and adapt to suit different needs. Car makers produce models which, although apparently different in style, make use of common components and floor pans or chassis. Semiconductor manufacturers like Intel and AMD spread the huge cost of developing new generations of chip across many product variants, and IBM's breakthrough in the personal computer industry was built on a platform architecture which was then opened to many players to create hardware and software applications, a forerunner of the business model of today's mobile phone apps (Remneland-Wikhamn *et al.*, 2011; Schaarschmidt *et al.*, 2019).

Many assert that digital innovations will disrupt existing businesses, services, and products. However, such claims misunderstand the notion of disruption. It is commonly misrepresented as the consequence of radical technological change, but the original conception of disruption is primarily about changes in how innovations create and capture value (Bessant and Tidd, 2018). For example, Uber is as much as a regulatory and employment contract disruption as it is a technological innovation (Laurell and Sandström, 2016). A critical distinction needs to be made between two types of innovation: (i) sustaining innovation, which continues to improve existing product functionality for existing customers and markets; and (ii) disruptive innovation, which provides a different set of functions which

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create value for a very different segment of the market. As a result, existing firms and their customers are likely to undervalue or ignore disruptive innovations, as these are likely to underperform existing technologies in terms of existing functions in established markets. This illustrates the danger of simplistic advice such as 'listening to customers', and the limitations of traditional management and marketing approaches. Therefore, established firms tend to be blind to the potential of disruptive innovation, which is more likely to be exploited by new entrants, as good practices such as segmentation of current markets and close relations with existing customers will simply reinforce sustaining innovation, but will fail to identify or wrongly reject potential disruptive innovations (Schweitzer and Tidd, 2018). Instead, firms must develop and maintain a detailed understanding of potential applications and changing users' needs. Therefore, rather than focus on the aggregate industry-level disruption, we instead need to identify which capabilities create value for specific products, applications, and markets, and carefully assess the potential for disruption of each (Kapoor and Eklund, 2018).

So, more recently, there has been growing attention on how innovation creates and captures value, so-called the 'business model innovation' (e.g., Casadesus-Masanell and Ricart, 2012; Gambardella and McGahan, 2010; Zott *et al.*, 2011). There is no single consensus definition of a business model, but Teece (2010, p. 127) suggests at the core is the "design or architecture of the value creation, delivery, and capture mechanisms". Thus, a business model should be able to link two dimensions of firm activity — value creation and value capture. Value creation and capture are linked by what is sometimes called "value delivery" (Casadesus-Masanell and Ricart, 2010). According to David Teece (2010), the 'business model' defines the way the company creates and delivers value to customers, and then captures a portion of this value to make profit and grow. Organizations which pursue this type of innovation develop novel value creation architectures and original revenue models, more than focusing just on new products or new services. Business Model Innovation (BMI) involves the integration and adaptation of capabilities, and the exploitation of these novel combinations to create and capture value in new ways (Gambardella and McGahan, 2010). However, studies focusing on the relationships between capabilities, business model innovation, and firm performance are rare (Schneider and Spieth, 2013).

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Schneider and Spieth (2013) argue that BMI "is simultaneously about the (re)deployment and usage of existing resources and capabilities to develop new value offerings or forms of value creation . . . the question of 'how' to use resources has been less considered" (pp. 4 and 15). Despite the increasing number of investigations in the field, much remains to be said. First, most of studies on BMI are conceptual (e.g., Koen *et al.*, 2011) or case-based (e.g., Casadesus-Masanell and Ricart, 2010; Desyllas and Sako, 2013), whilst quantitative investigations are limited. Second, and most important, these contributions have primarily addressed the capture and the monetization stage rather than its value creation architecture (e.g., Baden-Fuller and Haefliger, 2013; Desyllas and Sako, 2013; Witell and Logren, 2013). These contributions highlight the relevance of the issue, but often then they emphasize the client side, whilst they do not deepen under which conditions an innovative 'back-end' architecture may foster the competitive advantage and lead to a superior performance. In other words, literature has focused too much on the downstream options, but studies of the upstream or the 'back-end' of BMI are less common.

O'Mahony and Vecchi (2009) found the relationship between intangible assets and productivity to be higher in research and development (R&D)- and skill-intensive contexts. Similarly, Bueno *et al.* (2010) found that organizations require a diversified portfolio of resources, including both tangible and intangibles, to combine technological assets with other resources and capabilities, to create value. Demil and Lecocq (2010) investigated the dynamic created by the interactions of the different building blocks of business models. Sustained value creation instead relies on successfully shaping, adapting, and renewing the underlying business model of the company on a continuous basis, which comprises the rationale of how an organization creates, delivers, and captures value (Osterwalder and Pigneur, 2010). Denicolai *et al.* (2014) revealed the exploitation of tangible and intangible assets as complementary building blocks which compose the business model. Such complementary assets are central to the delivery of value, by leveraging monetizing opportunities, for example: "Systems integrators, platforms, and multi-sided markets share what is sometimes referred to as a business ecosystem. For managers, the ecosystems perspective holds the promise of opening up the wider entrepreneurial and collaborative space that a new technology

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affords, and provides room for novel business models to succeed" (Baden-Fuller and Haefliger, 2013, p. 424).

Such a systems perspective of BMI is needed, which comprises the rationale for how organizations create, deliver, and capture value. Exploiting a diversified portfolio of resources, both tangible goods and intangible services, boosts value creation opportunities. Many business models entail the exploitation of tangible and intangible assets as complementary building blocks. The combination of complementary assets is central to the delivery of value by leveraging monetizing opportunities by system integration found the relationship between intangible assets and productivity to be higher in technology- and skill-intensive contexts.

A useful way of better understanding the potential for, and impact of, digital innovation is the 4 'P's framework (Tidd and Bessant, 2018a):

- '***P***roduct innovation': Changes in the things (products/services) which an organization offers, for example, the growing functionality of mobile telephones;
- '***P***rocess innovation': Changes in the ways in which they are created and delivered, for example, the shift from physical media to streaming in music and video, or app-based applications such as food delivery and taxi services;
- '***P***osition innovation': Changes in the context in which the products/services are introduced, for example, the evolution of automation from factory, to services, the home, and transportation;
- '***P***aradigm innovation': Changes in the underlying mental and business models which frame what the organization does, for example, business model innovation and the bundling of products and services (see Table 1). Paradigm innovation can be triggered by many different sources: from new technologies, the emergence of new markets with different value expectations, new legal rules of the game, and changes in environmental conditions.

Figure 1 shows how these 4 'P's provide the framework for a map of the innovation space. The area indicated by the circle represents the potential innovation space within which an organization can operate. We can use the model to look at where the organization currently has innovation projects, and where it might move in the future. For example, if the

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Table 1. Examples of paradigm innovation.

Business model innovation	How value is created and captured, and by whom For example, peer-to-peer platforms and services, such as Uber, Ola, and DidiChuxing
'Servitization'	The bundling of products and services For example, AI connected home automation such as Amazon Echo and Google Home
Ownership to rental	For example, music and video streaming such as Spotify and Netflix, and car-sharing clubs
Offline to online	Internet-enabled substitution of physical encounters with virtual ones For example, retail shopping and gamification
Mass customization, personalization, and co-creation	New technologies and a growing desire for customization enable not only personalized products and services, but platforms on which users can engage and co-create For example, from toys (e.g., Lego), to clothing (e.g., Adidas)

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emphasis has been on product and process innovation, there may be scope for exploring more around position innovation, which new or underserved markets might we play in, or around defining a new paradigm, a new business model with which to approach the marketplace. We can also compare maps for different organizations competing in the same market, and use the tool as a way of identifying where there might be relatively unexplored space which might offer significant innovation opportunities.

The four types of innovation within the 4 'P's framework are not necessarily discrete, isolated strategies. Instead, they can combine and interact to create novel opportunities. For example, product and process innovation can combine to allow servitization, or positional innovation may demand changes in business models. Rather like Russian dolls, we can think of innovations which change things at the level of components or those which involve change in a whole system, in a recursive way (see Figure 2). For example, we can add a dedicated microprocesssor on a circuit board for the improved graphics capability in a computer, or to change the way several boards are put together into the computer to give it specific functionality — a games console, an e-book, or a media PC. We

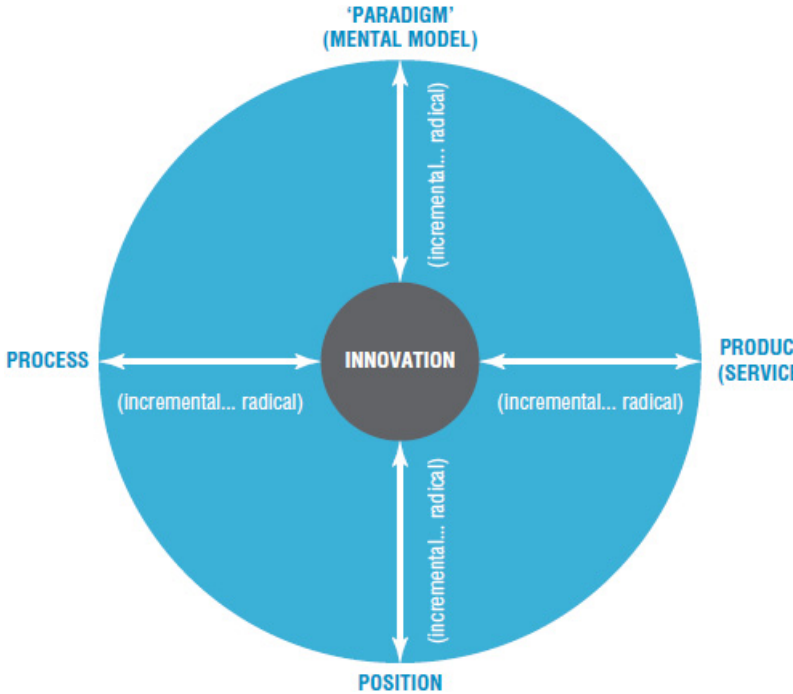

Fig. 1. The 4Ps of innovation space.
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can link computers into a network to drive a small business or office, or to create server farms, and these can form networks to others via the Internet. There is scope for innovation at each level, but more importantly, changes in the higher-level systems often have implications for lower down, and vice versa. For example, the Internet of Things (IoT) is built on low cost and low power processors, but its utility comes through aggregation and networking with cloud-based AI applications.

In such cases, successful innovation rarely involves dealing with a single technology or market, but rather, managing a bundle of knowledge which is brought together into a novel configuration. This requires the acquisition and application of knowledge about component-level innovations, but also the development of knowhow about how these can be put together, so-called the "architectural innovation" (Henderson and Clark, 1990). However, over time, a firm's product strategy, knowledge filters,

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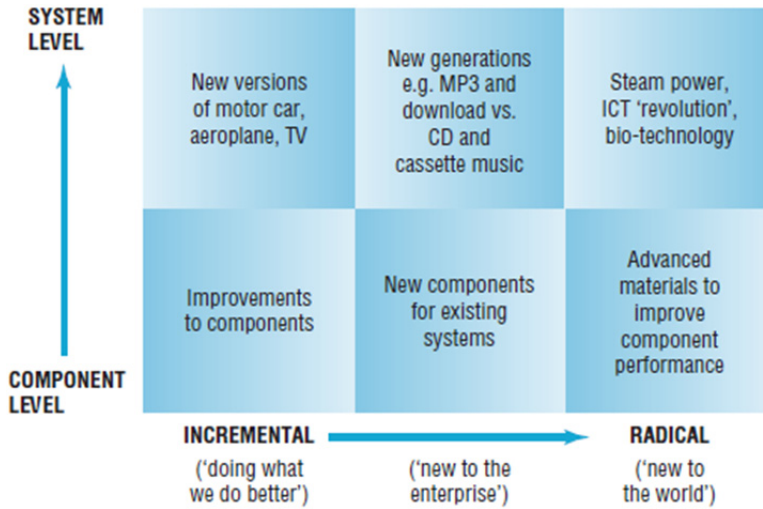

Fig. 2. Dimensions of innovation.
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and communication channels become organized around existing architectural knowledge. This makes it very difficult for established firms to identify the potential for new product and service configurations comprised of multiple technologies from different industries (Tidd, 1995), and helps to explain why a significant proportion of disruptive digital innovations are identified and exploited by new entrants rather than by established incumbent firms.

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