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A R T I C L E S

ARCHITECTURAL LEVERAGE: PUTTING PLATFORMS IN CONTEXT

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The use of the term *platform* has proliferated in management research. However, theoretical work on the concept has lagged behind. We present a systematic review of the platform literature, identifying four distinct streams: organizational platforms, product family platforms, market intermediary platforms, and platform ecosystems. Each of these streams is characterized by a distinctive, although usually implied, theoretical logic. We elaborate on the theoretical logics of leverage and architectural openness, both of which underpin all four streams of platform research. We further discuss three distinctive leverage rationales exhibited in different platform variants—production, innovation, and transaction—and illustrate how platform ecosystems combine aspects of all three. We explain the metalogic of architectural leverage to facilitate the purposive manipulation of platforms, providing a link between platform design features and sources of leverage. This provides a model that allows the different platform types to be placed into context with others. Finally, we outline how the concept of architectural leverage can be used to understand platform evolution.

The term *platform* has proliferated as both metaphor and construct in management research. It is used to describe management phenomena at the level of individual products, product systems, industry supply chains, markets, industries, and even constellations of industries (Gawer, 2009). Some claim that platforms will soon be a fact of life for managers and companies (Hagiu & Yoffie, 2009; Iyer & Davenport, 2008) and that any product can become a platform (Sviokla & Paoni, 2005). Our analysis of the ISI Web of Science Social Sciences Citation Index identified more than 900 business, economics, and management papers using the term in their title, abstract, or keywords.

As sometimes happens with phenomena described by appealing metaphors that appear to resonate with industry trends, there has been relatively little exploration of the theoretical underpinnings of the construct. Although there is a growing body of descriptive and case-based research, there is a relative dearth of platform research in A-journals in management.[1] Of the 183 articles identified in our survey of platform studies in management, 23 were published in A-journals; however, only seven of these are theoretical, and they are predominantly econometric in nature. Furthermore, to date there have been few attempts to integrate this literature (for an exception see Gawer, 2009). This lack of coherent theoretical grounding constrains the potential of this research to inform management theory and managerial practice. Our objective, therefore, is to draw on systematic literature review to create a coherent theoretical grounding for platform research (Tranfield, Denyer, & Smart, 2003).

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[1] We use the AACSB definition of A-journals, which is broader than the narrow list of A* journals.

We offer four distinct contributions in this paper. First, we organize the platform literature into streams, thereby making it more accessible for academics and practitioners alike. Second, we identify and discuss the underlying theoretical logics of leverage and architectural openness. This explication enables practitioners to focus on aspects of platform development that are most likely to yield competitive advantage. Third, to facilitate the purposive manipulation of platforms, we discuss the theoretical meta-logic of architectural leverage, elaborating on links between platform design features and sources of leverage. Finally, we outline how architectural leverage can be used to understand platform evolution.

THE LITERATURE USED IN OUR REVIEW

We conducted an extensive search of the ISI Web of Science Social Sciences Citation Index database for articles that used the term *platform** in their topic. We used the wildcard to capture plurals and any variants. To ensure that only relevant management research papers were reviewed, we excluded papers that used non-relevant dictionary meanings (such as a shoe), discipline-specific usages (such as from medicine), and methods-related usages (for example, a piece of equipment used in a procedure). We also excluded non-management journals. See the appendix for details of our review methodology.

TYPES OF PLATFORMS IN MANAGEMENT LITERATURE

A striking first observation is the dramatic growth in the use of the term *platform* in management research over the past two decades. Figure 1 details the growth of platform literature; the figures for 2010 represent the first three months.

A second observation is that the term *platform* has been given a range of different meanings. Variants of the term are used interchangeably (such as platform organization, platform investment, technology platform, platform technology, product platform, supply chain platform, process platform, industry platform, and so on). Rather than focusing on the variants of the term, however, we have focused on the contexts in which the term is used, and collated the different variants under a coherent theoretical logic. Table 1 details the four streams of research identified during the systematic review.

Categorizations such as the one in Table 1 are not new in this domain. A number of previous reviews of the platform literature exist, the most recent being those by Gawer (2009) and Gawer and Cusumano (2013). Gawer presented a typology of platforms that reflects a hierarchy of product systems. In our review, we explore the theoretical underpinnings of four different streams within the platform literature and identify theoretical meta-logics that underlie each stream: those of leverage and architectural openness. There are also a number of in-

FIGURE 1
Volume of Platform Papers by Stream

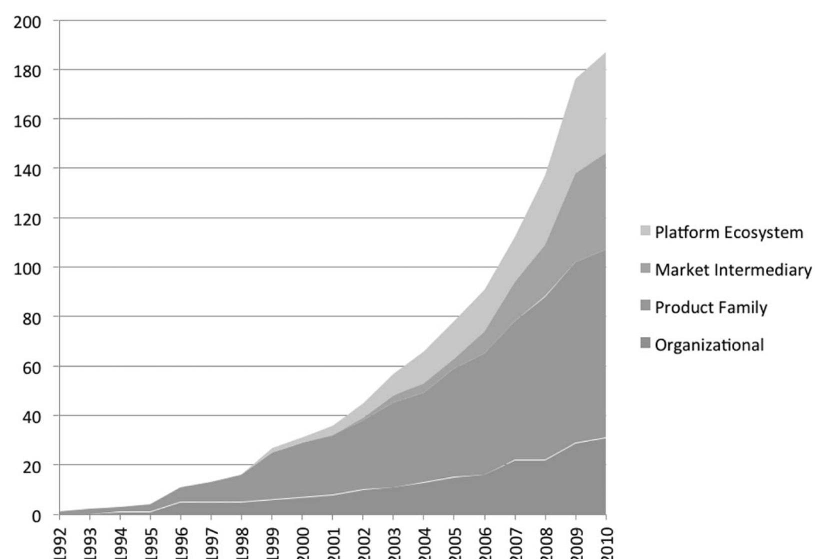


TABLE 1
Overview of Platform Streams

Stream	Organizational	Product family	Market intermediary	Platform ecosystem
Platform variants	Platform organization; platform investment; platform technology	Product platform; internal platform; supply chain platform	Multisided platform; two-sided platform	Industry platform; technology platform
Construct	Dynamic capability	Product family	Multisided market	Platform ecosystem
Description	Platform as organizational capabilities that enable superior performance	Platform as the stable center of a platform family leading to derivative products	Platform as an intermediary between two or more market participants	Platform as a system or architecture that supports a collection of complementary assets
Level of analysis	Firm	Product	Industry	System/industry
Core discipline	Corporate strategy	Product development	Industrial economics	Technology strategy
Key concepts	Core competencies; real options; dynamic capabilities	Product family; architecture; modularity; commonality	Network externalities; standards; multisided markets	Network externalities; innovation; standards; modularity
Value creation	Flexibility; superior adaptation	Flexibility; cost savings; innovation	Market efficiency; pricing structure; market power	Flexibility; cost savings; innovation; externalities; innovation; learning; market power
Value appropriation	Not applicable	Ownership; architectural control	Ownership; institutional mechanisms	Architectural control; ownership of critical elements; legitimacy
Papers at 2010	27 (15%)	76 (42%)	39 (21%)	41 (22%)
Empirical examples	Consulting; outsourcing; computing; biotechnology	Automotive; machine tools; consumer electronics; FMCG	Online auctions, price comparison, credit cards, telecoms, online advertising	Information technology, Internet
Main journals	*Harvard Business Review; Organization Science; Long Range Planning; International Journal of Technology Management*	*Journal of Product Innovation Management; Internal Journal of Production Research; Sloan Management Review*	*RAND Journal of Economics; Journal of Industrial Economics; Information and Economic Policy; International Journal of Industrial Organization*	*Research Policy; Technovation; Sloan Management Review; Journal of Industrial Economics; Journal of Economics and Management Strategy; International Journal of Industrial Organization; Management Science*
Main works	Ciborra (1996); Kim & Kogut (1996); Kogut & Kulatilaka (1994)	Meyer & Lehnerd (1997); Meyer & Utterback (1993); Robertson & Ulrich (1998)	Armstrong (2006); Caillaud & Jullien (2003); Rochet & Tirole (2002, 2003, 2006)	Bresnahan & Greenstein (1999); Gawer & Cusumano (2002); Gawer & Henderson (2007); West (2003)

formative summaries that focus on specific topics such as product platforms (Jiao, Simpson, & Siddique, 2007; Simpson, 2004) or two-sided market platforms (Rochet & Tirole, 2006). Product platform reviews are found in engineering journals and focus predominantly on engineering challenges in the management of product families. Market platform reviews are found in the economics literature. We add to these reviews by taking an overarching look at the different streams in the platform literature and by discussing the streams from a strategic management perspective. The four streams in our focus are organizational platforms, product family platforms, market intermediary platforms, and platform ecosystems.

For the *organizational platform stream*, the platform is a structure that stores an organization's resources and capabilities. This stream builds on organizational and dynamic capabilities literatures (Prahalad & Hamel, 1990; Teece, Pisano, & Shuen, 1997). For the *product family stream*, the platform enables a product family and supports effective development of product variants to address different market niches. Flexibility in product features supports mass customization and operational efficiency, and therefore the simultaneous pursuit of economies of scale and scope (Simpson, 2004). For the *market intermediary stream*, the platform enables a marketplace (typically, electronic), creating market efficiencies in two-sided markets. In this stream, the market platform provides the device for connecting supply and demand and establishes and exploits market power (Rochet & Tirole, 2006). For the *platform ecosystem stream*, the platform is a set of shared core technologies and technology standards underlying an organizational field that support value co-creation through specialization and complementary offerings. This is the most broad-based and heterogeneous stream and draws on a variety of theoretical perspectives, including industrial community, economic externality, and resource dependence perspectives (Cusumano, 2010; Cusumano & Gawer, 2002).

There is also a fifth stream, which we call the *general technology stream*, consisting of a limited number of papers ($n = 4$). This stream focuses on general-purpose technologies (Bresnahan & Trajtenberg, 1995) where generations of technology are subsequently built on dominant designs (Christensen & Rosenbloom, 1995; Kim, 2003). Here, the technology platform is the product of cumulative investments in R&D that generate families of technological options (Robinson, Rip, & Mangematin, 2007). This stream thus echoes the logic of Kuhnian (1962) scientific paradigms, where a set of core technologies both enables and constrains future innovation and technological development (Kim, 2003). In this stream of research, general technology platforms are not so much products, processes, or services, but intangible inputs to the macroeconomy that explain persistent cross-country differences in economic growth or productivity. General technology platforms are not sources of competitive advantage to be appropriated by a firm, but public resources to be shared through government research institutes.[2] As such, this stream tends to look to government policy (Distaso, Lupi, & Manenti, 2006; Thurow, 2000) and geographic clusters (Robinson et al., 2007). We do not develop this stream further, as it does not speak directly to the common notion of platforms as products, processes, and services within management. However, we felt it useful to point out the existence of this parallel stream to the management reader.

Organizational Stream

For the organizational stream, the platform is the organizational structure that stores organizational capabilities. This stream builds on the core competence (Prahalad & Hamel, 1990), organizational knowledge (Kogut & Zander, 1992), and dynamic capability (Eisenhardt & Martin, 2000; Teece et al., 1997) literatures, and it has been for the most part independent of the other streams, with little cross-referencing, although it represents 15% ($n = 27$) of the identified papers. It also has not been discussed in previous reviews of the platform literature. The organizational platform stream treats organizations as platforms that both carry organizational resources and capabilities and enable the rapid recombination of these to rapidly and flexibly adapt to shifting demands and address emerging opportunities. This dualism (i.e., the organization is the platform that supports its own dynamic capability) is achieved by distinguishing between lower-order and higher-order capabilities (Winter, 2003). Lower-order organizational processes comprise routines, resources, and processes that support the conduct of day-to-day transactions, whereas higher-order processes and structures support the pur-

[2] We thank Professor Paul Vaaler, Associate Editor of *Academy of Management Perspectives*, for suggesting the inclusion of general technology platforms.

poseful reorganization of lower-order processes to realign with shifting environments.

As a representative example, Ciborra (1996) described the "platform organization" as one that is capable of flexibly restructuring its resources and capabilities into new organizational structures in response to emerging business opportunities and challenges, such as those created by technological discontinuities. The platform organization recombines capabilities both internally within the organization, co-aligning the organization's routines and transactions, and through the wider network, where the re-architecting of capabilities and associated organizational structures is carried out (Ciborra, 1996). Similarly, an "organizational platform" is the cumulative and interdependent set of capabilities that have generative properties built into design elements and evolve to suit new contexts (Garud, Kumaraswamy, & Sambamurthy, 2006).

Thus, organizational platforms consist of collections of resources and capabilities that enable an organization to flexibly respond to changes in the market. One specific set of organizational capabilities developed in the literature consists of specialized technological capabilities that enable organizations to specialize in shared technology platforms (Kim & Kogut, 1996). This echoes the general technology stream above, but at a different level of analysis. "Platform investments" are real options created by investments in organizational capabilities that deliver operating flexibility or enable growth options that support investment strategies into a wide spectrum of opportunities (Kogut & Kulatilaka, 1994). Common to all these studies is the idea that organizations operate platforms of capabilities and resources that can be deployed to address and capitalize on shifting opportunities.

To summarize, platforms within the organizational stream contribute toward a reorientation of the firm's competitive scope and focus through capability buildup, combination, reorientation, and deployment. This stream thus directly reflects the capabilities-based organizational logic (Kogut & Zander, 1992; Prahalad & Hamel, 1990), where a platform represents a collection or specific architecture of resources that have been realized and deployed by dynamic capabilities (Winter, 2003).

Product Family Stream

The product family stream is the most widely researched field in the platform literature. It corresponds to the previous reviews of Simpson (2004) and Jiao, Simpson, and Siddique (2007), as well as to the notions of "internal platforms" and "supply chain platforms" discussed by Gawer (2009). Beginning from two influential papers (Meyer & Utterback, 1993; Wheelwright & Clark, 1992), there were 76 papers (approximately 42%) by mid-2010, as well as a number of influential books (McGrath, 1995; Meyer & Lehnerd, 1997) of the identified platform literature in management. Theoretically, this literature builds on innovation and product development research and echoes the resource-based logic of advantage creation. Salient influences on this stream include product development (Ulrich & Eppinger, 1994), product innovation (Utterback & O'Neill, 1994), architectural innovation (Henderson & Clark, 1990), modularity (Baldwin & Clark, 1997, 2000), and mass customization (Pine & Davis, 1999). Consistent with its emphasis on technology, the roots of this research are predominantly in the engineering management tradition, although there has been significant subsequent interest by management researchers (notably, in technology and innovation management), as well as by some economists. Contextually, the product family literature emanated from the automotive sector (Nobeoka & Cusumano, 1997), although other industry contexts include consumer power tools (Meyer & Lehnerd, 1997), computing industries (Meyer & Dalal, 2002), information products and services (Meyer & Zack, 1996), services generally (Meyer & DeTore, 2001), and high-reliability organizations (Bierly, Gallagher, & Spender, 2008).

In this stream, the platform is the stable common asset at the center of a product family. The concept of a product family is well established in engineering and product development, and the platform is integral to any definition. A product family addresses a specific market with product variants targeted at niches within that segment (Meyer & Lehnerd, 1997; Meyer & Utterback, 1993). Wheelwright and Clark (1992) considered platform projects to be focused on the needs of a core group of customers, designed for easy modification into derivatives for market niches through the addition, substitution, and removal of features. This definition does not clearly specify how modification occurs to create product variants, and the product platform concept has been applied to different types of modifications. One type is the scalable product platform, which has components that "stretch," so that variants possess the same function but with different capacities, such as within aerospace (Simpson, Maier, & Mistree, 2001). A second type is the generational product platform, which considers the product life cycle as the basis for rapid next-generation development, building on the distinction between product platform life cycle, product design life cycle, and product variant life cycle (Wortmann & Alblas, 2009). The third, and dominant, type in the literature is the modular product platform, where variants within the product family are created by interchanging modules (Meyer & Utterback, 1993).

The modular product platform has been considered in a variety of ways, although always within the context of product families. From a narrow technical perspective, a product platform can be defined as a collection of the common technological elements of the product family, such as the underlying core technology (McGrath, 1995). However, most definitions have taken an architectural perspective (Meyer & DeTore, 2001; Muffatto & Roveda, 2002), including features such as a common structure (Meyer, 1999), a central product design (Tatikonda, 1999), and interfaces between components (Halman, Hofer, & Vuuren, 2003). These perspectives emphasize how platform advantages are enabled by the technological architecture of the product, as expressed through modularization, connectivity, and interface standards.

The most common and influential definition of a product platform is that of Robertson and Ulrich (1998, p. 20), who define it as "the collection of assets shared by a set of products." These collections of assets comprise components, processes, knowledge, people, and their relations. Others have differentiated between internal platforms and supply chain platforms on the basis of manufacturing locus, noting that with the former, all assets are situated within the firm, and with the latter some are delivered by the supply chain (Gawer, 2009). Product family and product platform concepts have been extended to brands (Sawhney, 1998), regional operations (Ghemawat, 2005), customers (Sawhney, 1998), and processes (Jiao, Zhang & Pokharel, 2007; Meyer, Tertzakian, & Utterback, 1997).

To summarize, for the product family stream, the technical architecture of the product or service—as well as the structure of the underlying capabilities that deliver that product or service—operates as a platform the organization can leverage to enhance the flexibility and efficiency of its operations. The theoretical logic echoed in the management literature on product platforms thus echoes the resource-based and dynamic capability views, where product platforms either operate as valuable and hard-to-copy resources (Barney, 1991) or facilitate the rapid and flexible reconfiguration of the firm's other resources (Winter, 2003).

Market Intermediary Stream

The fastest growing area in the platform literature, the market intermediary stream, has been reviewed by Rochet and Tirole (2006) and as "double-sided markets" by Gawer (2009). Here, the platform represents a link or a facilitator between two or more markets or groups of producers and users. A market is considered two- or multisided when an intermediary can affect the volume of transactions by charging more to one side of the market and reducing the price paid by the other side (Rochet & Tirole, 2006). Although this is a relatively recent area of research, there were 39 papers, representing 21% of all papers included in this review. This perspective builds predominantly on the industrial economics tradition and has a strong econometric focus.

An early paper mentioning multisided markets was by Rochet and Tirole (2002), who studied the no-surcharge and interchange fees in the credit card providers market. This paper developed the first econometric model to describe the two-sided market phenomenon. This seminal paper was soon complemented by Caillaud and Jullien (2003), Rochet and Tirole (2003), and Anderson and Coate (2005), which together formed the basic building blocks of the multisided markets literature. Theoretically, this stream has evolved from research on network externalities, compatibilities, and competition (Katz & Shapiro, 1985; Laffont, Rey, & Tirole, 1998), building on the idea that price structures are less likely to be distorted by market power than price levels and that there are non-internalized externalities along end users (Rochet & Tirole, 2006). Contextually, the stream has emerged from considerations of the credit card industry (Rochet & Tirole, 2002), although this focus has since been extended to other sectors.

In the market intermediary stream, the dominant definition of a multisided market platform refers to a situation in which two or more agents interact through an intermediary (Armstrong, 2006). However, unlike traditional market intermediaries, multisided market platforms do not take ownership of the goods and services whose transactions they facilitate (Hagiu & Yoffie, 2009). Instead, multisided market platforms alleviate bottlenecks for buyers and sellers by facilitating their transactions with one another (Hagiu, 2006) and generate value for buyers and sellers through enhanced market efficiency, such as transaction volume, resource allocation efficiency, and an improved correspondence between supply and demand.

The multisided market platform is generally a service or product supplied by a given organization or a platform owner. Here, the specific design of that product or service enables multisided market intermediation (Belleflamme & Toulemonde, 2009; Martin & Orlando, 2007; Rochet & Tirole, 2006). More specifically, some scholars have differentiated between platform providers, which mediate users interactions, and platform sponsors, which control the technology and participation rights (Eisenmann, 2008). Thus, whereas product platforms are promoted through engineering and design features, pertinent features for the promotion of multisided market platforms include a specific product or service to facilitate market access, supply-demand intermediation, and associated pricing strategies (Boudreau & Hagiu, 2009; Evans, Hagiu, & Schmalensee, 2006).

To summarize, for the market intermediary stream, the platform acts as an interchange between multiple markets, and through its product or service architecture leverages one or more markets so the platform owner can profit from the additional value created through market intermediation. Theoretically, the multisided markets literature is based on considerations of market power (Katz & Shapiro, 1985; Laffont et al., 1998) along with resource-based views of competitive advantage (Barney, 1991).

Platform Ecosystem Stream

The platform ecosystem stream views the platform as a hub or a central point of control within a technology-based business system (Ceccagnoli, Forman, Huang, & Wu, 2012; Cusumano & Gawer, 2002; Gawer & Cusumano, 2008). This stream also incorporates Gawer's (2009) notion of the industry platform. The bulk of this stream contributes to the academic discipline of technology and innovation management, although there has also been interest from engineering and economics researchers. The stream currently makes up 22% (n = 41) of the platform literature. The seminal works of Bresnahan and Greenstein (1999) and Gawer and Cusumano (2002) have driven most of the subsequent research, although a number of earlier architectural-focused works such as Morris and Ferguson (1993) and Baldwin and Clark (2000) laid important theoretical foundations. In terms of theory, the platform ecosystem literature draws on a number of different perspectives, such as competitive strategy (Porter, 1985), value appropriation (Teece, 1986), and systems competition (Farrell, Monroe, & Saloner, 1998; Katz & Shapiro, 1994) within information technology industries (Shapiro & Varian, 1999). This stream also draws heavily on the work of Katz and Shapiro (1985, 1986, 1992, 1994) on the effect of network externalities on compatibility, technology adoption, product introduction, and systems competition, as well as research by Farrell and Saloner (1985, 1986, 1988, 1992) on the effect of compatibility on standardization, installed base, market and committee coordination, and system interfaces. Contextually, the platform ecosystem literature focuses predominantly on information technology and the Internet sectors, such as the computing industry (Bresnahan & Greenstein, 1999). Influential case studies in this stream include those of Intel (Gawer & Henderson, 2007), Cisco (Li, 2009), and Linux and Wikipedia (Garud, Jain, & Tuertscher, 2008).

The theoretical influences that underpin this stream reflect the fact that the platform ecosystem literature drew inspiration initially from the product family stream and later from the market intermediary stream. Similarly, papers within both the product family and market intermediary streams have recognized or anticipated the platform ecosystem stream. For example, in the product family stream, Meyer and Seliger (1998) anticipated the platform ecosystem phenomenon, and in the market intermediary stream, Economides and Katsamakas (2006), Eisenmann (2008), and Hagiu and Yoffie (2009) can be considered to incorporate aspects of the platform ecosystem stream. Unlike these streams of literature, however, there is no dominant definition of a platform, perhaps because there is no well-defined construct that provides conceptual boundaries to this stream similarly to the way the product family and the multisided market streams have a well-defined platform construct to underpin their discussion. Further, a platform ecosystem is typically more complex than either a product family or a multisided market, as it incorporates concepts from both product family and multisided market streams, such as those of modularity and market facilitation.

As the platform ecosystem literature incorporates both product family and market intermediary influences, understanding how platforms are described highlights the combination of the influences. On one hand, a platform is a bundle of components (Bresnahan & Greenstein, 1999), a system of separately developed pieces of technology (Cusumano & Gawer, 2002), or a subsystem in an evolving technological system (Gawer & Henderson, 2007). Here there is a strong theoretical emphasis on architectural design, interfaces, and modularity, influenced heavily by Baldwin and Clark (2000), and the theoretical logics also echo the resource-based view in their emphasis on the control of critical resources for superior performance. By contrast, unlike the product family stream but similar to the market intermediary stream, a platform facilitates the coordination of the efforts of buyers and sellers (Bresnahan & Greenstein, 1999) and acts as a hub of value exchanges (Economides & Katsamakas, 2006). Here the stream emphasizes the theoretical logics of market dominance and power.

These two logics are combined through the role of the platform in providing a coordination structure for a broader network of businesses (Cusumano & Gawer, 2002; Gawer & Cusumano, 2008) through organizing complementary assets, services, and technologies (Hagiu & Yoffie, 2009). The notion of complementary assets facilitating value creation in platform ecosystems also evokes attention to associated control mechanisms such as standards and standard setting (West, 2003), granting levels of access (Boudreau, 2010), and coordination benefits accorded by dominant designs (Suarez, 2004). In a platform ecosystem, the platform owner has relinquished ownership and control over components and modules of the product system, and as a consequence the platform ecosystem exhibits a diversity of ownership and control, of both complementary assets and the components that make up the platform (Cusumano & Gawer, 2002; Gawer & Henderson, 2007). The ecosystem participants leverage complementary assets accessible through the platform ecosystem to enhance their own performance (Boudreau, 2012; Ceccagnoli et al., 2012; Iansiti & Levien, 2004). In this manner, platform ecosystems incorporate the underlying logics of both the market intermediary and product family streams, and also evoke additional constructs and logics that address coordination challenges, such as dominant design, standards, and distributed ownership and control.

To summarize, a platform ecosystem represents the application of the product family logic of modularity, standards, and product differentiation to a product or service system broader than an internal or supply-chain–level product family. By relinquishing control of the overall product system, and by facilitating the integration of independent complementary products, the platform ecosystem stream incorporates theoretical elements of the market intermediary stream, such as direct and indirect network externalities and market power through the coordination of buyers and sellers. In addition, the platform ecosystem stream explicitly recognizes the importance of the resulting industrial community and surrounding ecosystem to the success of the platform.

These four streams represent a continuum from predominantly firm-internal platforms (organizational and product family platforms) to increasingly complex firm-external platforms (market intermediary platforms and platform ecosystems). Over time, a progression toward increasingly firm-external platforms is also visible. Whereas the work on firm-internal platforms has emphasized economies of scope and scale achievable through increased speed, flexibility, and efficiency, the work on firm-external platforms increasingly emphasizes market dominance and market power achievable through market leadership and network effects. This means that the platform literature has, over time, taken on increasingly strategic hues. Whereas the platform ideas originated in engineering management literature and in the context of product family design and management, the progression toward the application of platform thinking in network contexts makes it necessary to articulate the implications of this research for strategic management. We next discuss two theoretical logics that we see as key for understanding the strategic implications of this development—namely, those of leverage and architectural openness. These combine into a theoretical meta-logic of architectural leverage.

ARCHITECTURAL LEVERAGE

Above, we discussed four streams of management research focusing on platforms, highlighting commonalities and differences between the streams. While the theoretical underpinnings of the streams overlap to varying degrees, each stream reflects a distinct set of underlying theoretical logics. Common to all, however, appear to be the theoretical logics of leverage and architectural openness. We discuss these next.

Leverage

The concept of leverage, in the sense of exercising an influence that is disproportionate to one's size, constitutes an important commonality across the four streams of platform research in management. For instance, a textual analysis indicates that approximately 40% ($n = 74$) of the identified papers explicitly consider the concept of leverage in the context of platforms. At its most basic, leverage refers to a process of generating an impact that is disproportionately larger than the input required. In the context of strategic management, leverage is a direct driver of value creation and competitive advantage, as it provides a mechanism to achieve greater outputs from the same level of inputs, other things being equal. This competitive advantage can be reflected in systematically reduced cost or increased revenue, or dominance in markets with winner-take-all dynamics.

In platform contexts, leverage is achieved through developing shared assets, designs, and standards that can be recombined, thereby facilitating coordination and governance within and between firms sharing a given platform. Although the concept of leverage has been acknowledged within the platform literature, as demonstrated by the large minority of papers explicitly considering leverage, there has been little or no work distinguishing between different types of leverage and exploring the theoretical underpinnings of this concept. The concept of leverage has not been developed within the modularity literature either, with interest in this literature instead focused on modular operators such as splitting, optimizing, and augmenting (Baldwin & Clark, 2000). We develop the logic of leverage by identifying three types of leverage: production leverage, innovation leverage, and transaction leverage.

Production leverage is based on the (re)use of a collection of assets and the interfaces and standards that enable sharing these to drive economies of both scale and scope. This type of leverage is strongly present in the product family and platform ecosystem streams. In the case of product families, the reuse of production assets and product components helps realize both scale and scope economies through reduced manufacturing costs and through improved design quality, such as better product architecture (Krishnan & Gupta, 2001; Robertson & Ulrich, 1998). The sharing and (re)use of component designs, manufacturing processes, distribution channels, and suppliers also lead to reduced product development time in both platform and derivative product introduction (Jones, 2003; Krishnan & Gupta, 2001; Muffatto, 1999a; Robertson & Ulrich, 1998; Sawhney, 1998). For platform ecosystems, economies of scale and scope are realized not only in the same manner as in the product family stream, but also through the vertical disintegration of the supply chain that the ecosystem notion implies, with its emphasis on horizontal and vertical linkages between ecosystem participants. This means that the system is made up of multiple organizations, and hence design, production, and delivery activities are spread out over a range of organizations, each of which plays to its core strengths (Bresnahan & Greenstein, 1999). This deliberate distribution of design, production, and delivery assets enables superior economies of scale and scope through specialization and flexible combination of outputs.

Innovation leverage is similarly based on the (re)use of a collection of assets and the interfaces and standards that enable sharing. However, instead of sharing to achieve economies of scale and scope, the goal is to drive economies of innovation and complementarity and hence facilitate the creation of new goods and services (Boudreau, 2012; Meyer & Lehnerd, 1997; Nambisan & Sawhney, 2011; Wheelwright & Clark, 1992). This aspect is widely present within the organizational and product ecosystem streams, and it is also suggested within the product family stream.

For the organizational stream, leverage is achieved through the deployment of reusable capabilities to pursue shifting opportunities, thereby enabling innovation through complementarity and synergy (Ciborra, 1996; Kogut & Kulatilaka, 1994). This organizational leverage translates into competitive advantage by enabling the focal organization to reap the same positive outcomes of path-dependent organizational processes as those organizations that have invested more heavily into generating those outcomes internally (Kim & Kogut, 1996). For the product family stream, common interfaces and standards lead to improved performance through efficient creation of platform derivative products (Meyer & Dalal, 2002; Meyer & Lehnerd, 1997; Nobeoka & Cusumano, 1997), which can be extended more logically and consistently to new markets and geographies (Sawhney, 1998). When the product family is extended to supply chains and the platform system is decoupled from the focal firm, potential innovation benefits also emerge in the form of component innovation (Boudreau, 2010, 2012; Gawer, 2009).

For platform ecosystems, in addition to building upon the same economies of innovation as observed in the product family stream, both economies of innovation and complementarity are enhanced by the distribution of self-interested decision making across the ecosystem (Gawer & Henderson, 2007). For instance, by distributing the production and innovation of components across the ecosystem, not only can new system products be developed from existing components, but also, older components can be improved and new components developed. This distribution of decision making across the ecosystem drives the economies of both innovation and complementarity, giving rise to improved strategic flexibility for the platform owner (Gawer & Henderson, 2007).

Transaction leverage, in contrast, is based on the manipulation of the market pricing mechanism and market access, which drives transaction efficiency and reduces search costs in the exchange of goods and services (Eisenmann, Parker, & Van Alstyne, 2006; Rochet & Tirole, 2006). This idea of transaction leverage is echoed within both the market intermediary and platform ecosystem streams. For the market intermediary stream, transaction efficiency and reduction of search are achieved through the subsidization of one side of the platform to profit from another (Hagiu, 2006; Rochet & Tirole, 2006). Key to transaction efficiency and search is pricing, either through charging for access (also called membership) or charging for use (Rochet & Tirole, 2006). Beyond fee type, both the price level (the total price charged to both sides of the platform) and the price structure (the allocation of the total pricing between the sides) underpin how market intermediaries are able to leverage transactions to create value (Rochet & Tirole, 2006).

For platform ecosystems, the same economies of transaction and search of the market intermediaries are driven through network effects (Cusumano, 2010) that exist on all sides of the platform (Venkatraman & Lee, 2004). In the same manner as a market intermediary platform, a platform ecosystem also extracts the surplus value generated by leveraging its position as a value hub linking multiple sides of the market (Gawer & Cusumano, 2008). In this sense, the platform ecosystem leverages its position within an industry architecture to benefit from the economies of transactions and search (Jacobides, Knudsen, & Augier, 2006). Similarly, key to realizing this value is pricing such as the subsidization of one side of the platform to extract value from the other (Economides & Katsamakas, 2006).

To summarize, three types of leverage can be observed in platform contexts. Production and innovation leverage are both based on the use of shared assets and the related interfaces and standards that enable sharing. Production leverage is driven by economies of scale and scope, and is illustrated by the product family stream. Innovation leverage is driven by economies of innovation and complementarity, and is illustrated by both the organizational and the product family streams. Transaction leverage is driven by economies of transaction and search and is illustrated by the market intermediary stream. The platform ecosystem stream exhibits all three leverage logics, as the sources of leverage derive broadly from the multifaceted nature of the coordination among platform participants (Bresnahan & Greenstein, 1999).

Architectural Openness

Our review also identified *architectural openness* as a pervasive theoretical logic in the platform literature. Textual analysis indicates that approximately 52% (n = 96) of the identified papers explicitly consider the concept of architecture in the context of platforms, and approximately 31% (n = 57) explicitly consider openness and architecture together. We consider architecture as a system of elements and their relationships (Baldwin & Clark, 2000; Baldwin & Woodard, 2009; Crawley et al., 2004), which in platform contexts represents the result of deliberate, although at times path-dependent, design decisions (Ciborra, 1996; Eisenmann, 2008; Gawer & Cusumano, 2008; Muffatto, 1999b).

Conceptually, all platforms exhibit architectural features, in that they consist of a set of low-variety elements surrounded by more numerous high-variety elements (Baldwin & Woodard, 2009). For the organizational stream of platform literature, the stable set of capabilities and their structural relationships are important elements in considering them as a platform (Ciborra, 1996; Kogut & Kulatilaka, 1994). Within the product family and platform ecosystem streams, an architecture embodies the structural design, component mapping, and subsystem interfaces (Baldwin & Clark, 2000; Baldwin & Woodard, 2009) and has such importance to the product family that it has been used as a unifying construct for platforms (Muffatto & Roveda, 2002).

For platform ecosystems, a platform embodies sets of decisions regarding the level of modularization, interface openness, and information disclosure (Cusumano & Gawer, 2002; Richard & Devinney, 2005; Tiwana, Konysnski, & Bush, 2010). At the level of the industry, an architecture provides the template that describes the division of labor among a set of co-specialized participants (Jacobides et al., 2006). This aspect is also relevant for the market intermediary stream, where a platform provides an enabling infrastructure that underpins a market architecture, defined by a set of shared economic rules, such as protocols, rights, and pricing terms for transactions (Bakos & Katsamakas, 2008; Eisenmann et al., 2006; Eisenmann, 2008).

Architectures in platform contexts exhibit varying levels of openness to participation by parties other than the platform owner. The importance of platform openness in market intermediary and platform ecosystem contexts has been well documented by scholars (Boudreau, 2010; Eisenmann, Parker, & Van Alstyne, 2009; Gawer & Cusumano, 2002; Gawer & Henderson, 2007; West, 2003). Here, openness relates to the notion of visibility in modularity theory (Baldwin & Clark, 2000) and is best seen as analogous to the vertical strategy of Eisenmann and colleagues (2009), in that it considers the involvement of third-party suppliers for the production of both components and complements. Openness is construed as the level of value chain (dis)aggregation and the involvement of third-party suppliers of components and complementary services in the context of the industry architecture (Jacobides et al., 2006).[3] This concept of progressive opening of platform architectures aligns with Gawer and Cusumano's (2013) notion of internal and external platforms. Typical platform architectures include ones composed fully of firm-internal relationships, as well as one-to-many, many-to-one, and many-to-many configurations of relationships among suppliers, competitors, and complements.

A closed—or *firm-internal*—platform architecture has no third-party involvement. A platform becomes architecturally closed when restrictions have been placed on participation in its development, commercialization, and use (Eisenmann et al., 2009). As noted above, this type of architectural configuration is prevalent in both the organizational and the product family streams of literature. Within the organizational stream, platform organizations, platform investments, and platform technologies relate to those capabilities internal to the firm that can be combined to create value-adding combinations. Thus, platform organizations, platform investments, and platform technologies relate to those capabilities internal to the firm or can be combined with firm-internal capabilities to create value-adding combinations. Within the product family stream, architecturally closed platforms have been well documented by Gawer (2009), who has labeled them "internal platforms." These are typified by the platform projects of Wheelwright and Clark (1992), as well as the shared assets—such as firm-internal components, processes, knowledge, people, and their relations—highlighted by Robertson and Ulrich (1998).

A *many-to-one* architecture occurs where the supply side of the platform has been opened to third-party participants. A platform can be semi-open architecturally when restrictions have been relaxed on the supply side of the platform (Eisenmann et al., 2009). Many-to-one openness is exhibited in the product family stream, and was first explicitly introduced by Gawer (2009) as "supply chain platforms." For Gawer (2009) a supply chain platform is one where the platform "is no longer an internal affair" (p. 52), and differs from a firm-internal platform in that the design and manufacture of the components of the system is carried out by different suppliers along the supply chain, or among suppliers and a final assembler. A key example of a many-to-one architecture is that of automotive manufacturers.

A *many-to-many* architecture occurs where both the supply and demand sides of the platform have been opened to third-party participants. There are no restrictions on participation in development, commercialization, and use for either side of the platform (Eisenmann et al., 2009). Many-to-many architectures can be observed in both the market intermediary and platform ecosystem streams. For the market intermediary stream, the provision of both the supply- and demand-side high-variety components by third parties is integral to the definition of a multisided platform (Armstrong, 2006). For the platform ecosystem stream, participants from both the supply and demand side of the platform exemplify a many-to-many architecture, a typical example being the industry platform of Cusumano and Gawer (2002) and Gawer and Cu-

[3] In this manner, architectural openness aligns with existing notions of openness in platform contexts, but focusing attention on the architectural elements of openness.

sumano (2008). However, there can be varying levels of openness within a many-to-many architecture. For instance, selecting the right level of openness within a many-to-many architecture is crucial to the success of a platform, as it entails important trade-offs between participant adoption and value appropriation (Boudreau, 2010; Eisenmann et al., 2009; West, 2003).

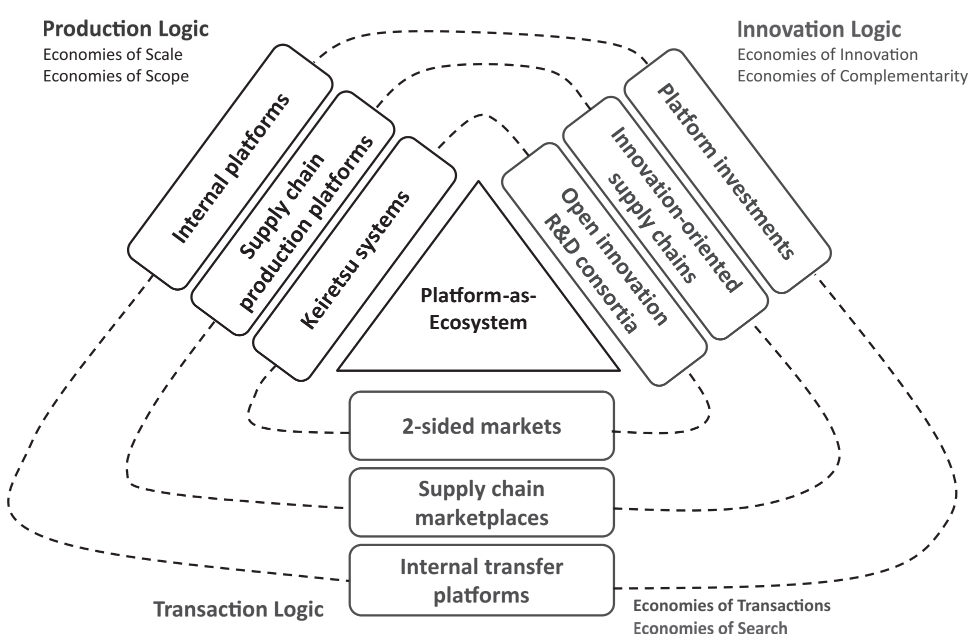
To summarize, the architectures of a platform system typically exhibit firm-internal, many-to-one, and many-to-many configurations. Firm-internal architectures are those that reside within the focal firm's boundaries and are most often observed in the organizational and the product family streams of literature. Many-to-one architectures are those where the industry value chain has been partially disaggregated with an open supply side, and such architectures are often observed within the product family stream. Many-to-many architectures are those where the industry value chain has been disaggregated, and both production- and consumption-side participants are free to participate. Many-to-many architectures are exhibited by both the market intermediary and the platform ecosystem streams.

Architectural Leverage

Combined, the logics of leverage and architectural openness suggest a meta-logic of *architectural leverage*. This meta-logic is echoed in "platform thinking," or the process of identifying and exploiting a shared rationale and structure in a firm's activities and offerings to achieve leveraged growth (Sawhney, 1998). By combining differing levels of architectural openness with production, innovation, or transactional leverage, a firm can achieve system-specific benefits by creating and sharing assets and systems. Figure 2 illustrates architectural leverage and the types of platforms and other phenomena that can be described by the meta-logic of architectural leverage. This model has the advantage of organizing the different types of platforms that exist in the literature into a coherent and consistent framework.

The combination of production leverage with architectural openness leads to the identification of three types of *production architectural leverage*. Production architectural leverage is based on the use of a relatively stable collection of production assets and resources, shared through interfaces and standards. These assets drive economies of scale and scope, resulting in an output that is greater than the effort expended. *Internal platforms* are those that are architecturally firm-internal and leverage shared assets and interfaces within the firm to achieve reduced development and manufacturing costs. Examples of internal platforms abound in the product family literature, covering those goods whose production processes involve manufactur-

FIGURE 2
Model of Architectural Leverage



ing, such as IBM's Series 360 (Gawer, 2009), electrical goods (Sanderson & Uzumeri, 1995), and power tools (Meyer & Lehnerd, 1997). *Supply chain production platforms* have a many-to-one architecture and leverage shared ordering platforms and system interfaces to achieve an output greater than the inputs required. A common example in the modern economy is the automotive platform, where a single organization controls the design of the platform and third-party suppliers provide the complements to the platform (Gawer, 2009; Nobeoka & Cusumano, 1997). *Keiretsu-type systems* have a many-to-many architecture and leverage shared product specifications and marketplaces. To date these have not been explicitly considered within platform contexts. However this conception of production logic leverage has been anticipated by Iansiti and Levien (2004), who introduced the idea of a platform to coordinate multiple producing organizations.

By combining innovation leverage with architectural openness, three types of *innovation architectural leverage* can be identified. Also based on a relatively stable collection of production assets and resources that are shared through interfaces and standards, innovation architectural leverage drives economies of innovation and complementarity that in turn lead to an innovation output that is greater than the effort expended. *Platform investments* are firm-internal and involve the leverage of shared resources and capabilities that enable operational flexibility and diversification (Ciborra, 1996; Kim & Kogut, 1996; Kogut & Kulatilaka, 1994). These bundles of resources are shared across the organization to better react to market conditions or to diversify into new markets. Examples include the acquisition of a robot platform to drive innovation and operational flexibility (Kogut & Kulatilaka, 1994) and the rapid reorientation of capabilities to address changing market conditions (Ciborra, 1996).

Innovation-oriented supply chains have a many-to-one architecture where the standards and interfaces on the shared assets are opened up to third parties. These shared assets are leveraged to achieve superior innovation within the supply chain. An example of this type of platform is the aerospace platform, as typified by Boeing's Dreamliner, where suppliers do not build to print but instead design and build to performance (Nambisan & Sawhney, 2011). *R&D consortia and open innovation* have a many-to-many architecture, where open standards and interfaces are leveraged to drive the development of new products and services by reaching out across multiple entity boundaries (Chesbrough & Appleyard, 2007). This type of leverage is exemplified by open-source projects, where both functional and process standards and interfaces are used for multiple parties to come together to create innovations. Although the term *platform* is normally used to represent the software that coordinates an open-source project, we extend the use of the term here in the spirit of Iansiti and Levien (2004).

The combination of transaction leverage with architectural openness leads to three types of *transactional architectural leverage*. Transactional architectural leverage is based on the use of the market pricing mechanism and market access to drive economies of transaction and search. This in turn leads to superior performance for the level of input. *Internal marketplaces* are firm-internal marketplaces where a shared pricing mechanism is leveraged to achieve more efficient pricing. An example is the use of transfer pricing protocols and procedures within many multidivisional companies. *Supply chain marketplaces* have a many-to-one architecture and leverage shared ordering platforms to reduce the cost of search and transactions. An example is procurement platforms, which became popular in manufacturing sector in the early 2000s, with many established to minimize sourcing costs (Kauffman & Mohtadi, 2004; Richard & Devinney, 2005). *Multisided markets* have a many-to-many architecture and leverage a shared trading platform to create and appropriate value from both sides of the market. Examples of multisided markets abound in market intermediary literature, including games consoles and online auctions (Evans et al., 2006).

Finally *platform ecosystems*, at the center of the diagram, represent a *multi-logic architectural leverage*, in that they combine production, innovation, and transactional architectural leverage into a many-to-many architecture. Platform ecosystems leverage production, innovation, and transaction logics based on an open system, through which they create and appropriate value. This type of architectural leverage, also called industry platforms, includes examples such as Intel and Cisco (Cusumano & Gawer, 2002; Gawer & Cusumano, 2008).

Platform Evolution

Platforms are able to evolve through different leverage logics and levels of architectural openness. Gawer (2009) first identified that platforms could evolve from a closed system toward greater openness. For Gawer, as components of an internal product platform are outsourced from external suppliers, the internal platform evolves into a supply chain platform. When the outsourced subsystems take on a life of their own and suppliers develop horizontal links among themselves, the supply chain platform evolves into a platform ecosystem. We build on this by proposing that platforms do not evolve along a single dimension of openness but can evolve along the leverage dimension as well. We suggest that, in addition to developing along a predefined openness trajectory, a platform can also change its leverage logic. This means that not only can a platform exist at any level of architectural openness with any leverage logic, but that a platform can also change its type of leverage logic through an evolutionary progression.

This evolutionary progression occurs as a platform owner seeks to take advantage of a differing leverage logic or opens the platform to allow others to participate. A platform owner can allow others to participate in the same manner as suggested by Gawer (2009), moving from a firm-internal to a many-to-one architecture through a progressive opening of its interfaces and standards, and in doing so build on the same leverage logic. However, in addition, a platform owner can move from one leverage logic to another. For instance, starting with production leverage, an internal platform owner can seek to refocus its leverage logic on innovation, by refocusing its efforts on efficient generation of product derivatives rather than cost reduction.

Taking this further, a platform owner can seek to change both leverage logic and architectural openness simultaneously, implying that an evolutionary progression from one level of architectural openness to another does not necessarily need to be within the same leverage logic. For instance, an internal platform can evolve from production logic to one that is innovation dominant and many-to-one by becoming an innovation-oriented supply chain platform. This would involve an opening of interfaces and standards to the supply chain and encouraging innovation-led leverage. An example here is the evolution of the aerospace platform. Initially firm-internal and production-oriented, aerospace platforms were focused on a production logic. However, with the Dreamliner, Boeing moved to an innovation logic in addition to moving to a many-to-one architecture (Nambisan & Sawhney, 2011). At any particular point in the platform's evolution, only one leverage logic will be dominant despite its previous leverage logics (except in the case of a platform ecosystem). In this manner each logic acts as a moderator on the action of the others, a fact well documented in management literature to date (for a discussion see Dodgson, Gann, & Salter, 2008).

A platform ecosystem hence represents a combination of three leverage logics, coordinated and orchestrated through the platform architecture. Becoming a platform ecosystem requires the integration of three leverage logics within an open system environment, coordinated by the management of modularity, network membership, network stability, innovation appropriability, innovation coherence, knowledge flows, and, importantly, innovation leverage (Nambisan & Sawhney, 2011). The challenge of evolving to this final stage is suggested by the range of platform leadership literature providing guidance and advice on platform dynamics (see, for instance, Brusoni & Prencipe, 2009; Cennamo & Santalo, 2013; Cusumano & Gawer, 2002; Eisenmann et al., 2009; Eisenmann, Parker, & Van Alstyne, 2011; Gawer & Cusumano, 2008; Zhu & Iansiti, 2012).

A further ramification of the interplay of multiple leverage logics is in understanding and integrating the various mechanisms suggested for platform ecosystem emergence. For instance, literature within the market intermediary stream has proposed several strategies based on the transaction leverage logic. Hagiu and Eisenmann (2007) have proposed a two-stage pricing model and Eisenmann (2008) a list of priorities for initial network creation. In contrast, the platform ecosystem literature has taken a more integrated approach, considering architectural openness with both production and transactional logics. For instance Bresnahan and Greenstein (1999) have considered the economic conditions for platform creation, and Gawer and Cusumano (2008) proposed "coring" as a way to create an industry platform. We suggest that the path first identified by Gawer (2009) may be the critical path to platform ecosystem creation, which is reflected in these mechanisms. However, we do not intend to imply that this would be the only path to become a platform ecosystem.

SUMMARY AND FUTURE DIRECTIONS

Platforms appear to be a phenomenon of central relevance for strategic management. The extensive body of platform research is relevant and timely, and its normative insights are having an impact on managerial practice. Research on platforms has proliferated in a wide range of contexts, giving rise to some degree of context specificity and idiosyncrasy in normative implications and undermining the coherence and cumulativeness of results. Responding to this challenge, several reviews have emerged. However, to date, a systematic examination of the theoretical logics evident in the platforms literature has been missing.

This review suggests several contributions for both theory and practice. We have consolidated and extended existing platform typologies (Gawer, 2009) and identified four streams in which the term and variants are used: organizational, product family, market intermediary, and platform ecosystem. As part of the stream identification we have explored the broader construct underlying each type of platform as well as the implied theoretical logics, aspects of platforms that have not been covered in the reviews in the literature to date. We have found that the theoretical underpinnings are often implicit (notably so in the platform ecosystem stream), implying a need to clarify the theories and constructs of each stream and to identify boundary conditions that regulate the applicability of platform strategies in different contexts. Similarly, given that we are still in the early stages of understanding how common and important the platform ecosystem stream really is (Cusumano, 2010), more empirical research beyond information technology and the Internet sectors is required to understand the boundary conditions of the platform ecosystem stream.

In addition, we have identified the importance of both leverage and architectural openness for platform research and synthesized a meta-logic of architectural leverage. This meta-logic is proposed as a unifying logic for research on platform strategies and as a framework for understanding different types of platforms seen in the literature. By explicating the three logics of leverage (production, innovation, and transaction) and the levels of value chain disaggregation that occur in platform contexts, we contribute to future cohesion and cumulativeness of empirical research on platform strategies. For instance, future research can focus on how different architectural configurations balance the three leverage logics in platform ecosystems and the resulting ecosystem dynamics. Alternatively, a potentially very fruitful research stream could focus on the dynamics of platform evolution, analyzing the shifts between different levels of architectural openness and the three leverage logics. In the way architectural leverage has been articulated in this paper, it should also offer guidance for research that seeks to elaborate normative implications for managerial practice. For instance, the identification of the three leverage logics provides practitioners insight into the sources of value creation within their platforms. We hope that the logic of architectural leverage presented here will contribute to a consolidation of the burgeoning platform literature.

A number of trends are apparent in the platform literature. There has been a progression from engineering-specific disciplines toward a more general application of platform thinking in strategic management. However, the translation of theoretical ideas from one academic discipline to another has not always been clearly articulated. A second related trend is that there has been a progression from simple technical hierarchies of products and product systems toward wider activity systems, as expressed in supply chain structures, industry networks, and industry knowledge architectures. This trend presents the challenge of migrating the underlying theoretical causation toward frameworks that are appropriate at each level of analysis. One manifestation of the trend toward wider industrial systems is found in the recent, rapid growth in the multisided markets literature. Although this did not originate in engineering and technical roots of the platform literature, it is beginning to be integrated. This stream (together with the platform ecosystem stream) also exhibits connectivity with other current trends in strategic management research, toward research on business models, open innovation, and industrial ecosystems. Future research focusing on the explication of the theoretical connectivity between these might provide for further consolidation of each of the associated literatures.

The trend in considering networked contexts presents the challenge of leveraging institutional, resource dependence, and sociological theories more explicitly for conceptual development. Whereas product families can be controlled reasonably well with intellectual property (IP) ownership and standards, the control challenge becomes much more complicated in technology-based industrial ecosystems, where sharing of IP is often the only means for generating systemic momentum, and where the emphasis is on innovation and exploration rather than exploitation and operational efficiency. In such situations, control increasingly rests on sociological and institutional devices rather than property rights. Scholars are beginning to address these devices, with participant trust covered in the market intermediary stream (Chen, Zhang & Xu, 2009; Dellarocas, 2010) and reputational and legitimacy concerns covered within the platform ecosystem stream (Gawer & Henderson, 2007; Gawer & Phillips, 2013). However, the platform literature could gain significantly from a more explicit integration of sociological and institutional literatures.

Our study has several limitations. Due to the scope and scale of the literature covered in this paper, it has not been possible to do full justice to the subtleties and complexities of both multisided market and platform ecosystem literatures, such as the assumptions and structure of the econometric models for the former and the complexities of the interaction among modularity, standards, and complementers and a full consideration of multisided market effects for the latter. Although there is an excellent review of product families (Jiao, Simpson, & Siddique 2007), there is an urgent need for a detailed systematic review with a deep analysis of the antecedents of each stream individually. This question is left for further research.

A further limitation is that this review has focused on the concept of platforms from a management and management research perspective. In developing our analysis of the theoretical underpinnings and boundaries of platform concepts, we are aware that multiple levels of analysis come into play. We do not explore the theory and practice of platform concepts beyond the level of the firm, although we have alluded to industry-, sector-, and ecosystem-level analysis, as well as the general technology stream. We believe further research and analytic work may be fruitful through the perspectives of different analytic lenses.

Limitations aside, several areas warrant further research in their own right. Much of the extant literature on platforms is derived from studies from the manufacturing sector, new product development, and the computing industry. This has created a particular understanding of the importance of platforms when applied to physical attributes. Yet more than 70% of economic activity is derived from services in OECD countries, and it is not clear how the concept of platforms translates from its application in products to services. We are aware that there are a number of exciting new research initiatives exploring the concept of platforms in services, the results of which have not yet been fully realized in the literature. There is no doubt, however, that this area would benefit from further research.

The architectural leverage meta-logic goes some way toward understanding platform value creation and value appropriation; however, this needs to be developed further. In addition, we believe that the meta-logic of architectural leverage can be developed into a robust theoretical model with formal propositions to provide cumulativeness and cohesiveness through a deeper theoretical grounding.

There is also a need for an understanding of the processes by which a platform is created. Our insight that platform evolution can occur along both architectural openness and leverage logics begins to shed some light upon this process. It has also enabled better understanding of the variety of emergence mechanisms proposed in the literature. However, no model to date considers how the complementary markets or the platform itself are initially created, nor has any model closely examined the underlying processes.

CONCLUSIONS

The term *platform* has been increasingly used over the past two decades, describing a range of phenomena relevant for management and management research. It is time to take stock of this idea and to assess whether a coherent body of literature is evolving. This paper presents four streams that describe the term in management research: organizational platforms, product family platforms, market intermediary platforms, and platform ecosystems. We identified three types of leverage that occur in platform contexts—production, innovation, and transaction—and different types of architectural openness that correspond to different levels of value chain disaggregation. Synthesizing these we identified and conceptualized the theoretical meta-logic of architectural leverage and situated types of platform variants within the architectural leverage framework. This contribution extends current thinking on platform evolution. Much work remains to be done to benefit from the insights the platform literature provides into the nature and dynamics of the modern economy. We hope this paper advances a coherent means of understanding platforms, and we also hope that it will inspire researchers to build on the concept of architectural leverage in a way that informs both theory and managerial practice.

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APPENDIX

We adopted an approach similar to that used in medicine, where systematic reviews are used to consolidate results of major studies on a particular topic (Higgins & Green, 2006). However, instead of a meta-analysis, for which a large number of relatively coherent empirical studies are needed, we adopted a framework synthesis approach. This approach creates a thematic synthesis of mostly qualitative literature that is not narrowly focused on a well-defined construct (Barnett-Page & Thomas, 2009; Oliver et al., 2008; Thomas & Harden, 2008).

We first searched the ISI Web of Science Social Sciences Citation Index database for articles that had *platform** in the topic field ($n = 4{,}280$). We used the wildcard to capture plurals and any variants. ISI is generally considered the most comprehensive database for scholarly work and includes thousands of journals. Although not all journals are included, ISI typically includes the most prominent journals. As the term *platform* has a number of common English meanings, there was substantial noise in the search results. It would have been possible to use other search terms to refine the search, but we discounted this approach as using any further search terms would risk biasing the results to academic areas we are particularly familiar with (Schildt, Zahra, & Sillanpaa, 2006). It would also have been possible to refine the search by restricting the results to key journals in which platform-related articles could exist as is common in management literature reviews (Brown & Eisenhardt, 1995). However, as the term *platform* is so broad, and as we are trying to understand the theoretical underpinnings of platforms within management research, this approach would have risked biasing the results to a particular meaning.

Instead, we read the abstract of each article and applied exclusion criteria. The first set of exclusion criteria was based on dictionary definitions ($n = 2{,}372$); the second on non-management discipline-specific usages, such as medicine, geology, aerospace, and education ($n = 605$); and a third set referring to installations of software internal to an organization or to a technology used as part of a method ($n = 1{,}022$). To ensure that only management literature was included, a final filter compared the data set with the journals listed by the *Academic Journal Quality Guide* of the Association of Business Schools ($n = 98$). The *Academic Journal Quality Guide* provides a guide to the range, subject matter, and relative quality of the journals in which business and management academics publish (Harvey, Kelly, Morris, & Rowlinson, 2010). The individual papers for the remaining documents were then downloaded ($n = 183$).

Each downloaded paper was read and coded to identify broad usages of the term, definitions, academic tradition, type of research, implied theory, value conditions, and key concepts, as well as to track interrelationships between each of the usages and concepts (Dahlander & Gann, 2010). A co-citation analysis identified the key referenced articles (Schildt et al., 2006; Schildt & Mattsson, 2006), providing a mechanism to highlight key concepts, theoretical bases, and invisible colleges (Gmur, 2003; Small, 1973). We produced tables and graphs of the papers, identifying patterns of coauthorship and the underlying literature.

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