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Architectural leverage: putting platforms in context

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Abstract

Management research on "platforms" has tended to race ahead of its theoretical underpinnings. We conduct a systematic review of the platform literature and identify four distinct streams: organizational capability platforms, product family platforms, market intermediary platforms, and technology system platforms. We propose the theoretical model of architectural leverage as a unifying framework for platform research. In our model, platform creation is enabled by three boundary conditions: technological architecture, activity architecture, and value architecture. These define the potential for platform value creation. The translation of this potential to firm-level performance is moderated by property rights ownership, architectural control, and trend leadership. We illustrate the model through an re-analysis of Intel, a

well-known case study.

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ARCHITECTURAL LEVERAGE: PUTTING PLATFORMS IN CONTEXT

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ABSTRACT

Management research on ‘platforms’ has tended to race ahead of its theoretical underpinnings. We conduct a systematic review of the platform literature and identify four distinct streams – organizational capability platforms, product family platforms, market intermediary platforms, and technology system platforms. We propose the theoretical model of architectural leverage as a unifying framework for platform research. In our model, platform creation is enabled by three boundary conditions: technological architecture, activity architecture, and value architecture. These define the potential for platform value creation. The translation of this potential to firm-level performance is moderated by property rights ownership, architectural control, and trend leadership. We illustrate the model through an re-analysis of Intel, a well-known case study.

INTRODUCTION

The use of the term ‘platform’ has proliferated in management research. It has been claimed 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). The term has been 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). A search of the ISI Web of Science Social Sciences index within business, economics and management topics indicates there were more than 900 papers that used the term in their title, abstract or keywords by Summer 2010. Thus, regardless of whether or not platforms are really becoming a ‘fact of life’ for managers, they appear to have become important for management researchers.

As sometimes happens with phenomena described by versatile and rather loosely defined terms that appear to resonate with pertinent industry trends, empirical research on ‘platforms’ appears to have raced ahead of its theoretical underpinnings. There is a growing body of descriptive and case-based research, which is often highly informative and relevant for managers and interesting in its own right. We contend that because of a lack of coherent theoretical grounding, cumulativeness has tended to suffer, constraining the potential of this line of research to inform strategic management theory. This is reflected in the relative dearth of theoretical platform research in management A-journals: of the 183 articles identified in our survey of platform studies in management, 23 had been published in A-journals; however only 7 of these are theoretical and are predominantly econometric in nature. This gap creates the risk of potential confusion, idiosyncratic normative implications, and, eventually, dwindling relevance of this research stream for practitioners and researchers alike. Our objective is, therefore, to re-introduce theoretical coherence into this promising area of study by carrying out a systematic literature review of platform research, and, building on this review, develop a theoretical model that articulates how salient platform mechanisms can be translated into competitive advantage (Tranfield, Denyer, & Smart, 2003). By identifying pertinent streams of platform research and articulating their implied theoretical logics, we seek to facilitate the transition of platform research from empirical and case-based studies toward cumulative, theory-grounded, and theory-testing research that informs theory and practice, and facilitates theory-grounded cumulativeness in research efforts in this domain.

Consistent with our ambition to explicate theoretical logic underlying platform research we distinguish between ‘organizational capability’, ‘product family’, ‘market intermediary’, and ‘technology system’ streams in this research. This categorization builds on recent reviews of the platform literature (notably Gawer, 2009) but departs from them with its focus on underlying theoretical logics rather than, for example, product system hierarchies. Each of the four streams is characterized by a distinctive, although usually implied, theoretical logic. From these streams, we identify that regardless of the level of analysis or the underlying theoretical logic, common to each of the four streams is the logic of leverage: the ultimate source of organizational advantage and value creation rests with the platform itself, and it is the platform that therefore becomes the focus of strategic maneuvering.

We develop a model of architectural leverage, in which value creation in platform contexts is enabled by three factors – technology architecture, activity architecture and value architecture – which also operate as boundary conditions for platform strategies. These boundary conditions also suggest control mechanisms that facilitate value appropriation by the focal firm, leading to firm-level performance for platform participants. Our model is useful for theorizing and predicting firm-level performance in platform contexts, and it should also facilitate strategy design and implementation in platform contexts. We then illustrate the architectural leverage model through an re-analysis of a well-known case studies, that of Intel by Gawer & Henderson (2007). We conclude by drawing implications for theory and practice, as well as identifying areas for future research.

METHOD

We adopted an approach similar to the systematic reviews in medicine, which 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 adopt a framework synthesis approach, creating a thematic synthesis of mostly qualitative literature that is not narrowly focused on a well-defined construct (Barnett-Page & Thomas, 2009; Thomas & Harden, 2008).

We first searched the Web of Science ISI Social Sciences Index database for articles that had 'platform*' in the topic field (n = 4280). 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. Due to the number of common English meanings, there was substantial noise in the search results. To reduce noise, the abstract of each article was read and exclusion criteria applied. The first set of exclusion criteria was based on dictionary definitions (n = 2372); the second based 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 = 1022). To ensure that only management literature were 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 & Mattsson, 2006), providing a mechanism to highlight key concepts, theoretical bases, and invisible colleges (Gmur, 2003; Small, 1973). The final list of papers is available from the authors.

REVIEW

The most striking observation from the systematic review is the dramatic growth in the usage of the term in management research over the past two decades. Figure 1 details the growth of platform related literature, with the figures for 2010 representing the first three months.

[Insert Figure 1 and Table 1 around here]

A second observation is that the meaning of the term 'platform' has not been consistent. 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 focus 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 this are not new in this domain. A number of previous reviews of the platforms literature exist, the most recent (and arguably the most comprehensive) being that by Gawer (2009). In her work, Gawer presented a typology of platforms based on a conceptual hierarchy of product systems, and in addition, Gawer also presented an evolutionary model of stage transitions for the first three.

In the present categorization, however, our focus is not on platform evolution, but instead on the distinct theoretical logics that underlie each category. Our interest is on the distinctive challenges of each category from the perspective of value creation and appropriation by platform participants. This implies an interest in the process that regulates those outcomes, and hence, an interest in the theoretical causation that drives value creation and appropriation. In our categorization, each steam is named after the broader construct providing the boundaries of the platform definition. This wider construct provides a collective name to encompass the relevant variant platform terms, avoids unnecessary focus on particular platform variants, and also broadly reflects the underlying theoretical logics.

The *organizational capability* stream considers a platform a structure that stores an organization’s capabilities, building upon organization and dynamic capabilities literatures (Eisenhardt & Martin, 2000; Teece, Pisano, & Shuen, 1997; Winter, 2003). Platforms within the organizational capabilities stream contribute toward a capability-based re-orientation of the firm’s competitive scope through capability build-up, combination, re-orientation and deployment (Ciborra, 1996; Kim & Kogut, 1996; Kogut & Kulatilaka, 1994). This stream thus directly reflects the capabilities-based organizational logic, where a platform represents a collection or specific architecture of resources and capabilities that have been realized and deployed by dynamic capabilities. Competitive advantage is achieved by leveraging this platform for the pursuit of opportunity, and value results from superior, proactive adaptation to environmental demands. In this stream, technologies play a secondary, instrumental role, as organizational capabilities are the primary driver of value creation.

The most dominant stream, by volume and maturity, is the *product family*, reflecting the early recognition of platform advantages for the development of product variants by the engineering discipline (Meyer & Utterback, 1993; Wheelwright & Clark, 1992). The dominant theoretical logic in this context echoes resource-based notions of organizational advantage, derived from operational efficiency, flexibility and scale economies (Barney, 1991; Teece, 1986). For the product family stream, the technical architecture of the product or service, as well as the structure of the underlying capabilities, operates as a platform which the organization can leverage to enhance the flexibility and efficiency of the its operations (Robertson & Ulrich, 1998), and, when extended to supply chains, also provides for potential innovation benefits in the form of component innovation (Gawer, 2009). Whereas the focus of the engineering-based literature is on techniques that facilitate product modularity and flexibility, the focus of the management literature is on harnessing this flexibility for operational efficiency, scale economies, market penetration and innovation (Krishnan & Gupta, 2001; Nobeoka & Cusumano, 1997). At the most basic level, internally controlled product families enable flexibility and cost savings, as variants can be rapidly built by varying components and their relationships, and as modules can be shared across products (Krishnan & Gupta, 2001; Robertson & Ulrich, 1998). Modular product structures also encourage specialization, which further promotes operational efficiency. The more the sub-systems are independent and components can be applied across platforms, the greater will be the opportunities to promote value creation through component and sub-system innovation by independent suppliers. In the logic of product family leverage, value appropriation rests on the incumbent's ownership and control of critical aspects of the platform assets and architecture.

The *market intermediary* stream resonates most closely with the theoretical logics of industrial organization economics, with the ultimate source of advantage in this stream being market power (Armstrong, 2006; Rochet & Tirole, 2006). The market intermediary stream is particularly concerned with pricing strategies in multisided markets, reflecting both the transactional nature of the platform and an underlying theoretical logic of market power. 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 that the platform owner can profit from another (Armstrong, 2006). Value is created through the leveraging of network externalities and identifying the optimal product or service design to facilitate interaction between the specialized participants (Hagiu, 2006). Multisided markets realize the surplus value enabled by the interaction of the multiple sides of the market through pricing strategies and rules (Eisenmann, 2008). Value appropriation rests upon ownership and control of the platform assets and architecture, the identification and management of winner take all dynamics, and favorable institutional conditions (Eisenmann, 2008).

The *technological system* stream is the most broad-based and heterogeneous and echoes the theoretical logics underlying each of the three previous streams, and, in addition, industrial community, economic externality, and resource dependence perspectives (Cusumano, 2010; Cusumano & Gawer, 2002). The technology system stream focuses on the platform as the hub of a technology system with indirect network effects (Cusumano, 2010). A technology system is 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 (Gawer, 2009; Gawer & Cusumano, 2002). By relinquishing control of the overall finished product and by facilitating the interaction of markets of suppliers of independent complementary products (Cusumano & Gawer, 2002; Gawer & Henderson, 2007), the technology system 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 (Bresnahan & Greenstein, 1999). In addition, the technology system stream explicitly recognizes the importance of the resulting industrial community and surrounding ecosystem to the success of the platform (Cusumano & Gawer, 2002; Gawer & Cusumano, 2008). Control and coordination concerns extend from the design of system modularity, interfaces and supporting standards (West, 2003), the design of a specific product or service required to link multiple markets (Hagiu & Yoffie, 2009), to the manipulation the community. Institutional mechanisms of control and leadership become increasingly relevant as the community grows beyond an integrator-dominated supply chain and the membership of the community grows more diverse. A technology system platform leverages both the technical and capability architecture of the product family, as well as that of the specific product or service design required for the market intermediary. The technology system stream is thus a complex interaction of the product family and market intermediary theoretical logics of resource based advantage and market power, with additional theoretical logics of legitimacy and trust arising from their interaction.

ARCHITECTURAL LEVERAGE

We have introduced four streams of management research focusing on platforms. Although the organizational capability, product family and market intermediary streams are quite distinct, the technology system stream has drawn heavily on both the product family and market intermediary streams. While the theoretical underpinnings of the streams overlap to varying degrees, each stream nevertheless reflects a distinct set of underlying theoretical logics. Common to all, however, is a meta-level theoretical logic, that of leverage. Drawing on the systematic review, we next develop a theoretical model of *architectural leverage* for value creation and value appropriation in platform contexts.

The concept of leverage, in the sense of having an influence greater than oneself, constitutes an important commonality across the four streams of platform research in management. For instance, a bibliometric analysis indicates that approximately 40% (n = 74) of the identified papers associate the concept of leverage in the context of platforms. At its most basic meaning, leverage refers to a process of generating an important impact with relatively little input. In the context of strategic management, leverage is a direct driver of competitive advantage. In platform contexts, leverage refers to the power to accomplish something, so that one has the ability to influence a system or an environment in a way that multiplies an outcome without a corresponding increase in the consumption of resources by the organization that is implementing the leverage. For the organizational stream, the platform enables leverage through the deployment of capabilities to achieve utility that is greater than the cost of the resources invested for achieving the leverage effect (Ciborra, 1996; Kogut & Kulatilaka, 1994). In the case of product families, leverage is realized through flexible product platforms (Meyer & Dalal, 2002; Nobeoka & Cusumano, 1997), as these enable cost-efficient creation of products to meet a variety of customer requirements (Meyer & Lehnerd, 1997). For the market intermediary stream, leverage is achieved through pricing strategies and market power enabled through the intermediation of multiple markets, as the market intermediary facilitates the subsidization of one side of the platform in order to profit from another (Hagiu, 2006; Rochet & Tirole, 2006). For the technology system stream, the sources of leverage are more varied but derive broadly from the multifaceted nature of the coordination between platform participants (Bresnahan & Greenstein, 1999) and direct and indirect network effects that enable the platform to become the hub of value creation and appropriation (Economides & Katsamakas, 2006; Gawer, 2009; Hagiu & Yoffie, 2009).

A related pervasive theme of the platform literature is the attention paid to architectural and design considerations. Platforms exhibit architectural features, in that they consist of a set of low-variety components surrounded by high-variety components (Baldwin & Woodard, 2009). From the product family and technological system perspectives, the system architecture embodies the structural design, component mapping, and sub-system interfaces (Baldwin & Clark, 2000). More specifically, for the product family stream, the platform itself is the result of a deliberate decision to optimize architecture decisions (Robertson & Ulrich, 1998). For technology systems, a platform embodies sets of decisions regarding level of modularization, interface openness, and information disclosure (Cusumano & Gawer, 2002). At the level of the industry, an architecture provides the template that describes the division of labor among a set of co-specialized firms (Jacobides, Knudsen, & Augier, 2006). This aspect is particularly relevant for the market intermediary stream, as it considers a platform as a market architecture defined by a set of shared economic rules, such as protocols, rights, and pricing terms for transactions in the context of an enabling infrastructure (Eisenmann, 2008; Eisenmann, Parker, & Van Alstyne, 2006). Organizational architecture has often been used to describe organizational structure (Brickley, Smith, & Zimmerman, 2004; Nadler, 1997). Hence, for the organizational stream, a platform is a particular set of organizational capabilities (Ciborra, 1996; Kogut & Kulatilaka, 1994).

Combined, the theoretical logic of leverage and associated architectural considerations suggest a model of *architectural leverage*, where the product, organizational, market, technological system, or industry-level architecture provides a lever for achieving outputs greater than the associated investments of resources and effort. This logic is echoed in ‘platform thinking’, or the process of identifying and exploiting a shared logic and structure in a firm’s activities and offerings to achieve leveraged growth (Sawhney, 1998). We therefore define architectural leverage as:

The process of leveraging technological architecture, activity architecture, and value architecture for the creation and appropriation of value through platforms.

In our model, the technological, organizational, and value factors operate as boundary conditions that regulate the creation of platforms that firms can then manipulate for value creation and value appropriation. Table 2 details each platform stream in terms of inputs, value creation mechanisms, and appropriation-enabling control mechanisms, and Figure 2 illustrates the theoretical model of architectural leverage.

[Insert Table 2 and Figure 2 around here]

The model identifies three boundary conditions that regulate both the creation of platforms as well as their amenability for value creation. Combined, these boundary conditions both regulate the creation of platforms and define their architecture. The resulting platform can then be leveraged for value creation. Value creation then drives performance at the level of the participating firms. However, this relationship is moderated by the degree to which platform participants have developed control mechanisms that enable them to appropriate the resulting value. Below, we elaborate specific propositions for each of the relationships identified in the model.

Technological Architecture

Technological design constitutes a key aspect of the architectural design of platforms, both of the artifact and the required capabilities. Technological architecture is a particularly important boundary condition for product families and technological systems, but it can also play a central role in multi-sided markets and organizational capability platforms as well. As identified in the systematic review, central design aspects underlying the creation of platforms include modularity, standardization, connectivity, and complementarity.

Modularity is an essential facilitator of product featuring at the product and systems level (Baldwin & Clark, 2000; Meyer & Utterback, 1993), and it can also be an important enabler of capability recombination flexibility at the organizational level (Koufteros, Vonderembse, & Jayaram, 2005; Sawhney, Wolcott, & Arroniz, 2006). In product systems, modularity facilitates the design and outsourcing of specialized components and sub-assemblies, thereby providing an important enabler of supply chains and technological ecosystems (Baldwin & Clark, 2000; Cusumano & Gawer, 2002;

Gawer, 2009; McGrath, 1995). Modularity necessarily requires a discussion of commonality and differentiation (Robertson & Ulrich, 1998), as a successful product system balances commonality potential and differentiation needs (Cusumano & Gawer, 2002; Halman, Hofer, & Vuuren, 2003).

Standardization is another essential technological design aspect facilitating the creation of platforms at all levels. In product families and technological systems, standardization of component features and sub-system interfaces constitutes, together with modularity, another important enabler of product featuring (Baldwin & Clark, 2000; Muffatto & Roveda, 2002). In technological business ecosystems, standardization is an essential facilitator of the creation of communities of interdependent platform participants (Cusumano & Gawer, 2002; West, 2003). Standards are also important to accelerate market development (Wonglimpiyarat, 2005), as standard-setting organizations identify and endorse important technologies and provide a path to industry coordination (Rysman & Simcoe, 2008). At the organizational level, standardization of procedures and engagement rules facilitates the flexible and efficient combination of organizational capabilities to address shifting opportunities (Ciborra, 1996; Garud, Kumaraswamy, & Sambamurthy, 2006). For market intermediaries, standardization of roles, rules, rights, and procedures facilitates effective governance of transactions and therefore, market efficiency (Bakos & Katsamakas, 2008; Eisenmann, 2008; Hagiu & Yoffie, 2009).

Connectivity is a direct corollary of modularity and standardization, and it provides an important glue for platforms, as it facilitates the co-specialization of assets, capabilities, and cognitive templates (Bakos & Katsamakas, 2008; Cusumano & Gawer, 2002; Meyer & Lehnerd, 1997). For product families and technological systems, connectivity among components and sub-systems is a necessary precondition for the production of technological performance through interactions between these (Baldwin & Clark, 2000; Robertson & Ulrich, 1998). In multi-sided markets, the platform itself operates as a connecting device between supply and demand. For organizational capability platforms, connectivity between organizational members and organizational capabilities provides for the deployment of organizational capabilities for the accomplishment of desired goals (Winter, 2003). Connectivity is also an important precondition of coordination among members of technological ecosystems, and therefore, knowledge exchanges, learning, and innovation among these (Wade, 1995).

Complementarity provides the final technological design driver of platform creation. Central to the notion of architectural leverage is that platforms enable the generation of a desired impact that is of significantly higher value than the cost of the resources required for this leverage. Much of this impact is derived from the synergistic interaction between platform sub-systems and capabilities. Because the sub-systems are heterogeneous, the creation of synergies is not achievable without complementarity (Gawer & Henderson, 2007). Similarly, for organizational capability platforms, the realigned and redeployed capabilities must be complementary in order to realize the value of the deployment (Ciborra, 1996; Garud et al., 2006).

Summarizing, therefore, we propose:

Proposition 1 *Platform creation is more likely in situations where there are technological and organizational design features such as modularity, standardization, connectivity, and complementarity.*

Activity Architecture

In addition to technological design architecture, the activities required for producing and operating platforms need to be orchestrated coherently. In this sense, activity architecture represents the second element of the architectural design of platforms, one that operationalizes its technological architecture both as a series of artifacts, and as organizational structures to utilize the technological artifacts. Essential organizing parameters in the platform context include specialization, addivity and coordination, discussed in detail below.

Specialization is a feature of modern economic organization (Nelson & Winter, 1982; Smith, 1994; Stigler, 1951), and consists of both the component and organizational specialization required for the production of the specialized inputs. Specialization emanates from the need to provide specialized inputs and organizational structures to support the product, technology, market, or organizational platform (Ciborra, 1996; Cusumano & Gawer, 2002; Gawer & Henderson, 2007; Robertson & Ulrich, 1998). For instance, product families often require specialized teams to coordinate multiple projects that overlap in time and which share critical components (Nobeoka & Cusumano, 1997) and hence also influences the structure and make-up of teams (Muffatto, 1999; Muffatto & Roveda, 2002). Similarly, technology systems often require specific organizational configurations such as keeping teams with similar goals under one executive and putting them in distinct departments (Cusumano & Gawer, 2002). From an organizational perspective, specialization enables concentration of effort, learning economies of scale, and therefore, greater efficiency on component production (Nelson & Winter, 1982; Smith, 1994). This enables individual participants to focus on specific platform inputs and therefore, indirectly, innovation (Cusumano & Gawer, 2002; Sawhney et al., 2006). Specialization of the individual technologies also facilitates flexibility, economies of scale and learning benefits.

Additivity is the operationalization of technological complementarity, so that there is a reduction in resource allocation overlaps. It facilitates the accumulation of specialized, complementary inputs, and it is therefore an essential facilitator of platform synergies. In the context of technical platforms such as product families and technological systems, additivity allows the proliferation and readjustment of product and system features for alternative uses (Cusumano & Gawer, 2002; Meyer & Utterback, 1993; Robertson & Ulrich, 1998). In the context of multi-sided markets, additivity provides for the creation of direct and indirect externalities, and therefore, greater market efficiency (Armstrong, 2006; Rochet & Tirole, 2004). In multisided markets, additivity refers facilitates the collective performance of hierarchical tasks, and therefore, the accomplishment of desired goals (Ciborra, 1996; Kim & Kogut, 1996; Kogut & Kulatilaka, 1994). Thus, additivity is an integral feature of the organization of tasks and roles in all platform contexts.

Coordination facilitates the leveraging of the platform for value creation, and is necessary for the hierarchical task execution to enable the smooth operation of the platform. Depending on the size of the platform community, coordination mechanisms can range from top-down, hierarchical coordination through established lines of command to lateral and informal coordination, for example, through the communication of technological trends and the propagation of social roles and behavioral norms (Ciborra, 1996; Cusumano & Gawer, 2002; Garud et al., 2006; West, 2003). In internal product platforms, coordination is achieved through design rules, organizational hierarchy, and architectural design templates (Baldwin & Clark, 2000; Gawer, 2009; Morris & Ferguson, 1993), while in supply chain platforms, coordination is similarly achieved through design templates, assisted by interface standardization (Gawer, 2009). In multi-market platforms, coordination is achieved through the rules, roles, and procedures embedded in the platform itself and communicated to market participants

(Bakos & Katsamakas, 2008). In all of these situations, coordination enables synergistic allocation of effort so as to realize the value potential created by the platform.

Therefore, we propose:

Proposition 2 *Platform creation is more likely in situations where the activity architecture benefits from the appropriate specialization, addivity and coordination among platform participants.*

Value Architecture

Value drivers are key enablers of architectural leverage, as they determine which control mechanisms are effective. One set of value drivers are those that are supply side, such as cost efficiencies, as well as scale and scope efficiencies. Product families, and to a lesser extent technology systems, are primarily concerned with economies of production product development, such as integration benefits leading to economies of scale and speed, giving an increased ability to react, and design benefit, such as reduced time, cost and effort.

A second set of value drivers are centered on demand side. A key factor for consumption centered economics are network externalities which are a shared economic characteristic of both multisided markets and technology systems (Katz & Shapiro, 1985, 1986, 1994). Network effects also lead to winner-take-all dynamics in both multisided markets (Eisenmann et al., 2006) and technology systems (Cusumano, 2010). Network effects can be distributed across different networks including competitors due to multi-homing (Corts & Lederman, 2009), and not necessarily equally balanced (Bakos & Katsamakas, 2008). Network effects can also affect other inputs, such as the number of complementors (Gandal, Greenstein, & Salant, 1999). Thus we propose:

Proposition 3 *Platform creation is more likely in situations where there are value drivers such as network externalities, scale economies, and innovation benefits.*

Platform Creation

The above discussion has identified boundary conditions for platform creation. Each of these boundary conditions influence the nature of the platform by defining the potential value that can be created. This means that boundary conditions both function as thresholds, in that certain conditions must met in order to create a successful platform, and as regulators, in that changes to these boundary conditions can change the potential value.

This value potential consists of the integration of the applicable elements of the boundary conditions and their interaction shapes the nature of the particular platform. Table 2 details the various combinations of boundary conditions that lead to the value potential of specific platform contexts. Thus if the technological architecture has viable modularity, standardization, complementarity and connectivity conditions, and these are sufficiently operationalized through coordination, speciation and addivity within the activity architecture, and the value architecture includes externalities, innovation, efficiency and flexibility benefits, then the value potential represented by the combination of these boundary conditions could be realized by the creation of a technology system platform. Alternatively, if the value architecture did not contain externalities, but the technological architecture was adequate and it was sufficiently operationalized by the activity architecture, then the value potential could be realized as a product family platform. The same logic applies for market intermediary and organizational platforms. Although the technological architecture is not as fundamental for these two types of platforms, considerations of complementarity, standardization and connectivity are still important, as they underpin how the individual elements of the activity architecture are operationalized.

However this value potential remains simply potential until the organization actually creates the platform. Subject to the technological, activity and value architecture boundary conditions, the organization must create and control the platform in order to create and appropriate value for performance at the organizational level. For organizational capability platforms platform creation activities are internal to the firm, such as capability realignment or acquisition (Ciborra, 1996; Kogut & Kulatilaka, 1994). For product families, in addition to capability realignment or redeployment, there are design considerations, such as modularity and commonality, and as well as market and value architecture understanding (Meyer & Utterback, 1993; Wheelwright & Clark, 1992). For market intermediaries and for technology systems, not only are there the underlying technological architectures to consider, but the organization must mobilize the multiple sides of the network to make the platform core to the market, subject to the constraints of the value architecture and the activity architecture. Thus for proprietary platforms the organization needs to bring both sides on board, assess network effects to see which side to subsidize, and navigate any winner take all dynamics (Eisenmann, 2008). This role is further complicated if the platform is shared, as timing, IP management and diplomacy all become important (Eisenmann, 2008). In addition, for technology systems it is also important to make the platform core to any technical system so that resolves outstanding technical problems (Gawer & Cusumano, 2008).

Summarizing, we propose:

Proposition 4 *The boundary conditions of technological architecture, activity architecture, and value architecture regulate the value potential of a platform.*

Organizational Performance

In our model, platforms enable the creation of value through operational efficiency, scale economies, innovation, and community-level learning externalities. These regulate the creation of value in platform contexts and are potentially available for all platform participants. The boundary conditions can be used by platform participants to gain leverage and achieve organizational performance, with different conditions exhibiting varying salience in different platform contexts. Through the manipulation of these boundary conditions by control mechanisms, organizations can create the value creation and appropriability conditions that are most suitable for themselves. The organization can then maximize the appropriation conditions for themselves through the control mechanisms discussed below. The value potential is realized through the creation of the platform level, and is translated into organizational performance at the firm level through the control mechanisms. Given the variety of platform contexts, organizational performance can take the form of sales growth through market creation and control, operational efficiency through scale economies and co-specialization, innovation through learning and knowledge creation, and profitability through enhanced value creation.

Summarizing, we propose:

Proposition 5 *Platforms enhance organizational performance among participating organizations.*

Control Mechanisms

The above benefits do not automatically translate into organizational performance, however. Participating organizations can leverage platforms for enhanced performance only if they retain sufficient control over value appropriation. In our systematic review, we identified three salient control mechanisms that regulate the ability of platform participants to appropriate the value created through platform leverage. These are: ownership of property rights, architectural control, and trend leadership. Together, these control mechanisms moderate the relationship between value creation through platform leverage and value appropriation by individual platform participants.

Ownership of property rights is a salient control mechanism for product families, technological systems, and market intermediaries. However, as indicated by the systematic review, the ownership of all aspects of the platform is not necessary to secure value appropriation. For superior value appropriation, it suffices if the firm retains control of critical platform components and interfaces. This is well illustrated by the example of Microsoft and Intel in the context of the PC ecosystem: for an extended period of time, these two incumbents exhibited levels of profitability that were far superior to that of PC manufacturers (Cusumano & Gawer, 2002). The level of ownership of the critical components can also vary from pure proprietary, asset ownership with open standards, to open source in parts or in whole (West, 2003). Olleros (2008) has argued that at times simple openness is not enough, and decentralization of the platform itself is required for it remain successful and maintain innovation. Ownership can also be divided, and market forces tend to push both proprietary and shared platforms over time toward hybrid licensing forms, typified by central control over platform technology and shared responsibility for serving users (Eisenmann, 2008). Overall, property rights ownership tends to be more salient and complete for internal product platforms and multi-sided market platforms, whereas the ownership of strategic aspects of the platform may be sufficient in supply chain and technology system situations, where the strategic release of aspects of platform rights may be necessary to set value creation processes in motion (West, 2003).

Architectural control is a powerful control mechanism for product families, technological systems, and market intermediaries. Architectural control mechanisms include adjusting the level of modularity, adjusting the level of access, and adding functionality. Varying the level of modularity affects the variety and differentiation within product families (Voordijk, Meijboom, & De Haan, 2006). In contrast, for technology systems, modularity is a pragmatic design approach which harnesses incompleteness in a generative manner (Garud, Jain, & Tuertscher, 2008). This means that modularity evolves over time as the organization facilitates the involvement of ecosystem participants (Cusumano & Gawer, 2002; Spinello, 2005), while maintaining overall system stability (Olleros, 2008). Adjusting the level of access, or the ability for third parties to participate in the ecosystem, also moderates the effect of platforms on performance. The level of access drives the amount of innovation that occurs around the platform (Cusumano & Gawer, 2002; Gawer & Cusumano, 2008). Adding functionality also acts as a powerful moderator on organizational performance. By combining functionality with that of a competitor's offering, an organization can increase the appeal of their platform and decrease that of others (Eisenmann et al., 2006). By identifying or designing a functionality to be fundamental to a technological system as well as to a market, or by absorbing and bundling those from an adjacent market, an organization can achieve superior returns (Gawer & Cusumano, 2008). Organizations that move into complementary markets may risk deterring ecosystem members from participating. However, at times this the only mechanism to maintain momentum of the platform (Gawer & Henderson, 2007). Overall, architectural control is more important for product families and technology systems, whereas the control over access to the multiple markets is more important for market intermediaries.

Trend leadership is an control mechanism most salient to technology systems, market intermediaries and organizational capability platforms. For organizational capability platforms, key to maintaining flexibility and coherence of the underlying capabilities within their realignment and redeployment is identity building (such as culture, mission, market position, design skills and so on) so that organizational participants have a consistent narrative to follow (Ciborra, 1996). For technology systems and market intermediaries, trend leadership is broader than the platform itself, as it must necessarily include the participants in the linked markets and ecosystem. A key element of trend leadership is maintaining the continued relevance of the platform to all participants, both in the past and in the future (Gawer & Cusumano, 2008). As the membership of the community grows more diverse, and the requirement for technological relevance more pressing, in addition to identity building, mechanisms to build trust and reputation are also vital. For instance, proving ability, benevolence and integrity are key to building and maintaining trust (Mayer, Davis, & Schoorman, 1995) so that platform participants continue to enter and generate value with the platform (Chen, Zhang, & Xu, 2009; Gawer

& Henderson, 2007). Reputation management provides a mechanism to continually prove the appropriateness and the legitimacy of their leadership position in the ecosystem. Legitimacy is vital so that the platform owner can focus the attention of the community and articulate challenges for the community to resolve through problem definition, prioritization and solution leadership. In all, through the trend leadership control mechanisms an organization can build identity, reputation, trust and legitimacy in order to appropriate value from the platform.

Summarizing, we propose:

Proposition 6 *Control mechanisms moderate the degree to which individual platform participants will be able to appropriate platform value and translate this into organizational performance.*

DISCUSSION

This paper has examined the prevalence of the term platform in management literature, as well as the lack of clarity as to what a platform actually means within management research. Through a thorough systematic review of the literature, four streams of platform research were identified: organizational capability, product family, market intermediary and technology system. In synthesizing these four streams, we have identified architectural leverage as a unifying construct, and which provides a theoretical basis for understanding platform creation. Below we illustrate architectural leverage with a well-known empirical example.

We take the analysis of Intel by Gawer & Henderson (2007), which considers technology system platform owner innovation and entry into complementary markets, in this case chipsets. This is a good example to use as it describes the strategic actions of an existing successful platform owner, and where the relevant platform covers the majority of the elements of our model. In our analysis we take the initial architectural boundary conditions as given, and illustrate how the various elements of architectural leverage model influence organizational performance through an examination of Intel's strategies. Gawer and Henderson explore Intel's strategy with respect to complements, finding that entry decisions are shaped by the belief that it does not have the capabilities to enter all possible markets, and thus it must encourage widespread entry despite the fact that potential entrants rationally fear Intel's ability to 'squeeze' them *ex post.* One of the findings was that Intel would only enter what it would consider 'connector' markets, in which the products embody one or more of the interfaces between the platform and the end use applications, and where it had core competences. In the language of architectural leverage, this is an example of adjusting the technological architecture and value architecture boundary conditions through the exercise of the architectural control and trend leadership mechanisms. By exercising the architectural control mechanism, the technological architectural boundary conditions were adjusted by adding additional functionality. Additional support for the technological architecture boundary condition was driven by the fact that Intel had the relevant core competences. This action also changed the value architecture as the existence of the improved chipset not only positively affected Intel's product development and marketing efficiency and flexibility, it also extended demand for the main processor. The exercise of the trend leadership mechanism was through the justification given to "advance the platform" and "accelerate platform transitions", emphasizing Intel's leadership position in the market and influencing the value architecture further. However, this move into the complementary market presented Intel with the dilemma, in that external third parties would fear Intel and would be reluctant to enter and participate in the ecosystem. To reduce this fear, Intel relies upon a number of primary mechanisms to signal that it does not engage in an *ex post* squeezing of entrants. Firstly, Intel uses an internal organizational structure of separate divisions and a widely publicized rhetorical device of separating demand expansion and profitability tasks. Secondly, it further contributes to the activity architecture boundary conditions by creating a separate organizational unit for stimulating demand for microprocessors, explicitly structured as a cost center. Finally, by the development and distribution of IP it attempts to reduce the cost of entry to all potential entrants, Intel uses the property rights ownership control mechanism to influence the value architecture for all participants in the ecosystem. In all, the discussion of the Intel study above illustrates theoretical validity of the architectural leverage model through an analysis of platform change.

CONCLUSION

Overall, this review highlights the prevalence of platforms research, as well as some strengths, weaknesses, and trends. The dominating impression from our review is that platform research is clearly onto something. There is no escaping of the conclusion that platforms are a phenomenon of central relevance for strategic management. The extensive body of platform research, only a small portion of which was sampled here, is clearly relevant and timely, and its normative insights are clearly impacting managerial practice. At the same time, however, research on platforms has proliferated to a wide range of different contexts, giving rise to some degree of context specificity and idiosyncrasy in normative implications and undermining the coherence and cumulativeness of platforms research. Responding to this challenge, a number of reviews have emerged recently, the present one included. 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. First, we have consolidated and extended existing platform typologies (Gawer, 2009) and identified four streams. As part of the stream identification we have explored the theoretical construct underlying each type of platform as well as value creation and appropriation logics. We have found that the theoretical underpinnings in all four streams are often implicit (notably so in the technology system 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.

Second, we have developed a generally applicable model of architectural leverage, and we have also illustrated the usefulness of this model through a re-analysis of a well-known case study. This model is proposed as a unifying framework for research on platform strategies. In our review, we observed that all streams echo an underling theoretical logic of leverage. By explicating the logic of leverage in platform contexts, we contribute toward future cohesion and cumulativeness of empirical research on platform strategies. In the way the model has been articulated in this paper, it should also offer guidance for research that seeks to elaborate normative implications for managerial practice.

On the basis of this review, a number of trends are apparent in the platforms literature. As noted, there has been a progression from engineering-specific disciplines towards 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. There has also 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, as well as leveraging institutional, resource dependence, and sociological theories more explicitly for conceptual development. Whereas product families can be controlled reasonably well with 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. 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 justice to the subtleties and complexities of both multisided markets and technology systems, such as the assumptions and structure of the econometric models for the former, as well as the complexities of the interaction between modularity, standards, and complementors, as well as a full consideration of multisided market effects, for the latter. A second limitation is that in developing our analysis of the theoretical underpinnings and boundaries to platform concepts we are aware that multiple levels of analysis come into play. This paper does not explore the theory and practice of platform concepts beyond the level of the firm, although we have alluded to industry and sectorial level analysis.

Limitations aside, a number of 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 is 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.

Secondly, our model goes someway to understanding the boundary conditions required for platform creation, however the architectural leverage propositions need to be operationalized for more detailed research, refinement and predictive power. For instance, the model would benefit from an understanding of the different threshold levels for each boundary condition, the role of context on boundary thresholds and inter-relationships, and threshold level change in the presence of other boundary conditions.

Beyond the conditions for platform creation, there is also a need for a understanding of the processes by which a platform is created. The market intermediary literature has proposed a two stage model from the perspective of pricing (Hagiu & Eisenmann, 2007) and a list of priorities for initial network creation of both proprietary and shared platforms (Eisenmann, 2008). Within the technology system literature, Bresnahan & Greenstein (1999) have considered the economic conditions for platform creation, Gawer & Cusumano (2008) have proposed ‘coring’ as a way to create an industry platform, and Gawer (2009) an evolution from product families to industry platforms. However, no research to date considers how the complementary markets or the platform itself are initially created, nor has closely examined the underlying processes.

In conclusion, the term platform has been increasing in use over the past two decades, describing differing phenomenon in management research. It is timely to take stock of this idea and, and to assess whether a coherent body of literature is being developed. This paper presents four streams which describe the term in management research: organizational capability platforms, product family platforms, market intermediary platforms and technology system platforms. We have synthesized these four streams and identified architectural leverage as the unifying construct. We hope that this is a more coherent means of understanding platforms, and that this paper will inspire researchers to build on architectural leverage in a meaningful way.

REFERENCES

Armstrong, M. 2006. Competition in two-sided markets. ***Rand Journal of Economics***, 37: 668-691.

Bakos, Y., & Katsamakas, E. 2008. Design and Ownership of Two-Sided Networks: Implications for Internet Platforms. ***Journal of Management Information Systems***, 25: 171-202.

Baldwin, C. Y., & Clark, K. B. 2000. ***Design Rules: The Power of Modularity Volume 1***. Cambridge, MA, USA: MIT Press.

Baldwin, C. Y., & Woodard, C. J. 2009. The architecture of platforms: a unified view. In A. Gawer (Ed.), ***Platforms, Markets and Innovation***: 19-44. London: Edward Elgar.

Barnett-Page, E., & Thomas, J. 2009. Methods for the synthesis of qualitative research: a critical review. ***BMC medical research methodology***, 9: 59.

Barney, J. B. 1991. Firm resources and sustained competitive advantage. ***Journal of Management***, 17: 99-120.

Bresnahan, T. F., & Greenstein, S. 1999. Technological competition and the structure of the computer industry. ***Journal of Industrial Economics***, 47: 1-40.

Brickley, J. A., Smith, C. W., & Zimmerman, J. L. 2004. ***Managerial economics and organizational architecture***.

Chen, J., Zhang, C., & Xu, Y. 2009. The Role of Mutual Trust in Building Members' Loyalty to a C2C Platform Provider. ***International Journal of Electronic Commerce***, 14: 147-171.

Ciborra, C. U. 1996. The platform organization: Recombining strategies, structures, and surprises. ***Organization Science***, 7: 103-118.

Corts, K. S., & Lederman, M. 2009. Software exclusivity and the scope of indirect network effects in the U.S. home video game market☆. ***International Journal of Industrial Organization***, 27: 121-136.

Cusumano, M. A. 2010. The evolution of platform thinking. ***Communications of the ACM***, 53: 32.

Cusumano, M. A., & Gawer, A. 2002. The elements of platform leadership. ***MIT Sloan Management Review***, 43: 1-8.

Dahlander, L., & Gann, D. M. 2010. How open is innovation? ***Research Policy***, 39: 699-709.

Economides, N., & Katsamakas, E. 2006. Two-Sided Competition of Proprietary vs. Open Source Technology Platforms and the Implications for the Software Industry. ***Management Science***, 52: 1057-1071.

Eisenhardt, K. M., & Martin, J. A. 2000. Dynamic capabilities: what are they? ***Strategic Management Journal***, 21: 1105-1121.

Eisenmann, T. R. 2008. Managing proprietary and shared platforms. ***California Management Review***, 50: 31-53.

Eisenmann, T. R., Parker, G., & Van Alstyne, M. W. 2006. Strategies for two-sided markets. ***Harvard Business Review***, 84: 92.

Gandal, N., Greenstein, S., & Salant, D. 1999. Adoptions and orphans in the early microcomputer market. ***Journal of Industrial Economics***, 47: 87-105.

Garud, R., Jain, S., & Tuertscher, P. 2008. Incomplete by Design and Designing for Incompleteness. ***Organization Studies***, 29: 351-371.

Garud, R., Kumaraswamy, A., & Sambamurthy, V. 2006. Emergent by Design: Performance and Transformation at Infosys Technologies. ***Organization Science***, 17: 277-286.

Gawer, A. 2009. Platform dynamics and strategies: from products to services. In A. Gawer (Ed.), ***Platforms, Markets and Innovation***. Cheltenham, UK.

Gawer, A., & Cusumano, M. A. 2002. ***Platform leadership: How Intel, Microsoft, and Cisco drive industry innovation***. Boston, MA: Harvard Business School Press.

Gawer, A., & Cusumano, M. A. 2008. How companies become platform leaders. ***MIT Sloan Management Review***, 49: 28.

Gawer, A., & Henderson, R. M. 2007. Platform owner entry and innovation in complementary markets: Evidence from Intel. ***Journal of Economics & Management Strategy***, 16: 1-34.

Gmur, M. 2003. Co-citation analysis and the search for invisible colleges: A methodological evaluation. ***Scientometrics***, 57: 27-57.

Hagiu, A. 2006. Pricing and commitment by two-sided platforms. ***Rand Journal of Economics***, 37: 720-737.

Hagiu, A., & Eisenmann, T. R. 2007. A Staged Solution to the Catch-22. ***Harvard Business Review***, 85: 25-27.

Hagiu, A., & Yoffie, D. B. 2009. What's Your Google Strategy? ***Harvard Business Review***, 87: 74-81.

Halman, J., Hofer, A., & Vuuren, W. 2003. Platform-Driven Development of Product Families: linking theory with practice. ***Journal of Product Innovation Management***, 20: 27-47.

Harvey, C., Kelly, A., Morris, H., & Rowlinson, M. 2010. Academic Journal Quality Guide, 4th ed.: ABS - The Association of Business Schools.

Higgins, J. P. L., & Green, S. 2006. Conchrane Handbook for Systematic Review of Interventions 4.2.6. In J. P. L. Higgins, & S. Green (Eds.), ***The Cochrane Library***, 4 ed. Chichester, UK: John Wiley & Sons.

Iyer, B., & Davenport, T. H. 2008. Reverse engineering Google's innovation machine. ***Harvard Business Review***, 86: 58-69.

Jacobides, M. G., Knudsen, T., & Augier, M. 2006. Benefiting from innovation: Value creation, value appropriation and the role of industry architectures. ***Research Policy***, 35: 1200-1221.

Katz, M. L., & Shapiro, C. 1985. Network externalities, competition, and compatibility. ***The American Economic Review***, 75: 424-440.

Katz, M. L., & Shapiro, C. 1986. Technology adoption in the presence of network externalities. ***Journal of Political Economy***, 94: 822-841.

Katz, M. L., & Shapiro, C. 1994. Systems competition and network effects. ***Journal of Economic Perspectives***, 8: 93-115.

Kim, D. J., & Kogut, B. 1996. Technological platforms and diversification. ***Organization Science***, 7: 283-301-283-301.

Kogut, B., & Kulatilaka, N. 1994. Options thinking and platform investments: Investing in opportunity. ***California Management Review***, 36: 52-71.

Koufteros, X., Vonderembse, M., & Jayaram, J. 2005. Internal and external integration for product development: The contingency effects of uncertainty, equivocality, and platform strategy. ***Decision Sciences***, 36: 97-133.

Krishnan, V., & Gupta, S. 2001. Appropriateness and impact of platform-based product development. ***Management Science***, 47: 52-68-52-68.

Mayer, R. C., Davis, J. H., & Schoorman, F. D. 1995. An integrative model of organizational trust. ***Academy of Management Review***, 20(3): 709-734.

McGrath, M. E. 1995. ***Product Strategy for High Technology Companies***. Homewood, IL: Irwin.

Meyer, M. H., & Dalal, D. 2002. Managing platform architectures and manufacturing processes for nonassembled products. ***Journal of Product Innovation Management***, 19: 277-293.

Meyer, M. H., & Lehnerd, A. P. 1997. ***The power of product platforms: building value and cost leadership***: Free Press.

Meyer, M. H., & Utterback, J. M. 1993. The product family and the dynamics of core capability. ***MIT Sloan Management Review***, 34: 29.

Morris, C. R., & Ferguson, C. H. 1993. How architecture wins technology wars. ***Harvard Business Review***, 71: 86-96.

Muffatto, M. 1999. Platform strategies in international new product development. ***International Journal of Operations & Production Management***, 19: 449-459.

Muffatto, M., & Roveda, M. 2002. Product architecture and platforms: a conceptual framework. ***International Journal of Technology Management***, 24: 1-16.

Nadler, D. 1997. ***Competing by design: The power of organizational architecture***.

Nelson, R. R., & Winter, S. G. 1982. ***An Evolutionary Theory of Economic Change***. Cambridge, MA, USA: Harvard University Press.

Nobeoka, K., & Cusumano, M. A. 1997. Multiproject Strategy and Sales Growth: the Benefits of Rapid Design Transfer in New Product Development. ***Strategic Management Journal***, 18: 169-186.

Olleros, X. 2008. The lean core in digital platforms. ***Technovation***, 28: 266-276.

Robertson, D., & Ulrich, K. 1998. Planning for product platforms. ***MIT Sloan Management Review***, 39: 19-32.

Rochet, C., & Tirole, J. 2004. Two-Sided Markets: An Overview.

Rochet, J. C., & Tirole, J. 2006. Two-sided markets: A progress report. ***Rand Journal of Economics***, 37: 645-667.

Rysman, M., & Simcoe, T. S. 2008. Patents and the Performance of Voluntary Standard-Setting Organizations. ***Management Science***, 54: 1920-1934.

Sawhney, M. S. 1998. Leveraged high-variety strategies: From portfolio thinking to platform thinking. ***Journal of the Academy of Marketing Science***, 26: 54-61.

Sawhney, M. S., Wolcott, R. C., & Arroniz, I. 2006. The 12 different ways for companies to innovate. ***MIT Sloan Management Review***, 47: 75-81.

Schildt, H. A., & Mattsson, J. T. 2006. A dense network sub-grouping algorithm for co-citation analysis and its implementation in the software tool Sitkis. ***Scientometrics***, 67: 143-163.

Small, H. 1973. Co-citation in the scientific literature: A new measure of the relationship between two documents. ***Journal of the American Society for Information Science***, 24: 265-269.

Smith, A. 1994. ***The Wealth of Nations***: Modern Library.

Spinello, R. A. 2005. Competing Fairly in the New Economy: Lessons from the Browser Wars. ***Journal of Business Ethics***, 57: 343-361.

Stigler, G. J. 1951. The division of labor is limited by the extent of the market. ***Journal of Political Economy***, 54(3): 185-193.

Sviokla, J., & Paoni, A. 2005. Every Product's a Platform. ***Harvard Business Review***, 83: 17-18.

Teece, D. J. 1986. Profiting from technological innovation: Implications for integration, collaboration, licensing. ***Research Policy***, 15: 285-305.

Teece, D. J., Pisano, G. P., & Shuen, A. 1997. Dynamic capabilities and strategic management. ***Strategic Management Journal***, 18: 509-533-509-533.

Thomas, J., & Harden, A. 2008. Methods for the thematic synthesis of qualitative research in systematic reviews. ***BMC medical research methodology***, 8: 45.

Tranfield, D., Denyer, D., & Smart, P. 2003. Towards a Methodology for Developing Evidence-Informed Management Knowledge by Means of Systematic Review. ***British Journal of Management***, 14: 207-222.

Voordijk, H., Meijboom, B., & De Haan, J. 2006. Modularity in supply chains: a multiple case study in the construction industry. ***International Journal of Operations & Production Management***, 26(5).

Wade, J. 1995. Dynamics of organizational communities and technological bandwagons: An empirical investigation of community evolution in the microprocessor market. ***Strategic Management Journal***, 16: 111-133.

West, J. 2003. How open is open enough? Melding proprietary and open source platform strategies. ***Research Policy***, 32: 1259-1285.

Wheelwright, S. C., & Clark, K. B. 1992. Creating project plans to focus product development. ***Harvard Business Review***, 70: 70-82.

Winter, S. G. 2003. Understanding dynamic capabilities. ***Strategic Management Journal***, 24(10): 991-995.

Wonglimpiyarat, J. 2005. Standard competition: Is collaborative strategy necessary in shaping the smart card market? ***Technological Forecasting and Social Change***, 72: 1001-1010.

Figure 1 – Volume of Papers by Stream

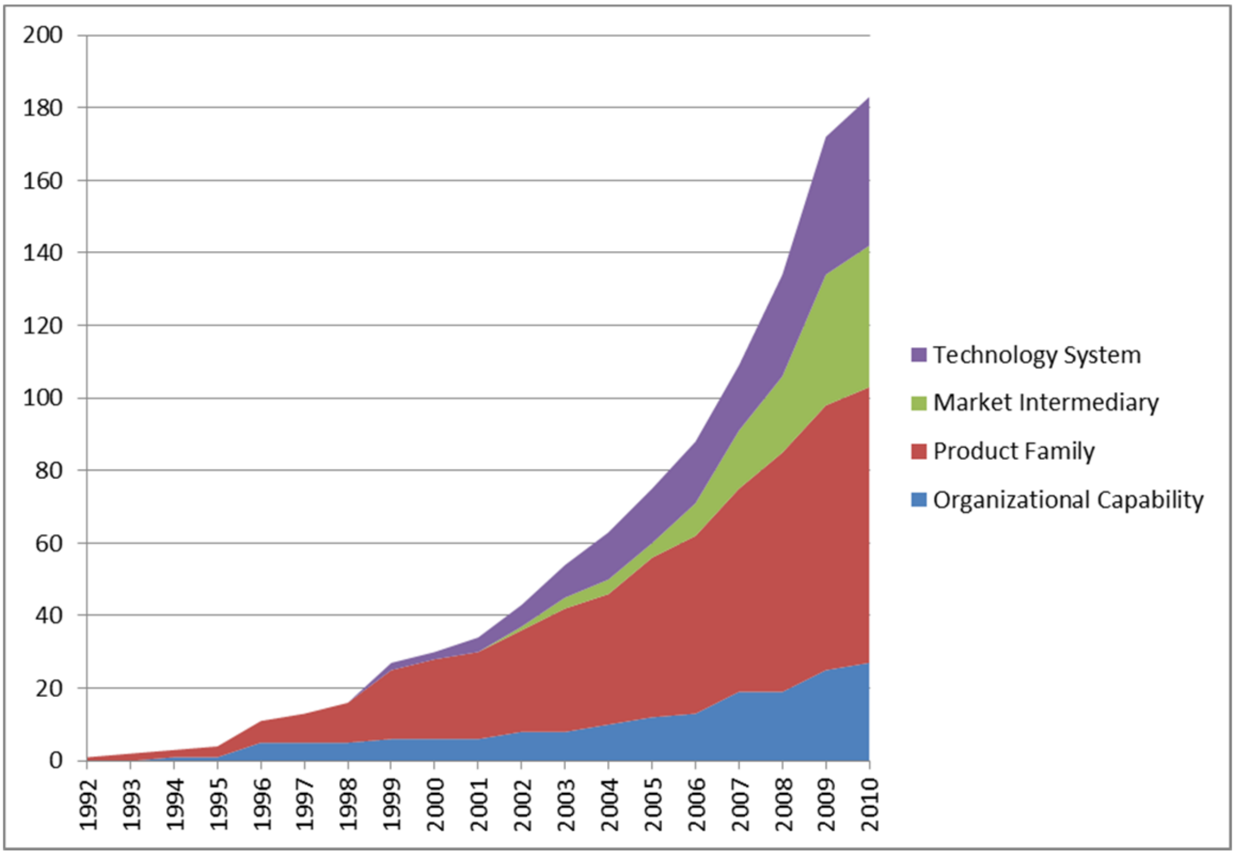

Figure 2 – Model of Architectural Leverage

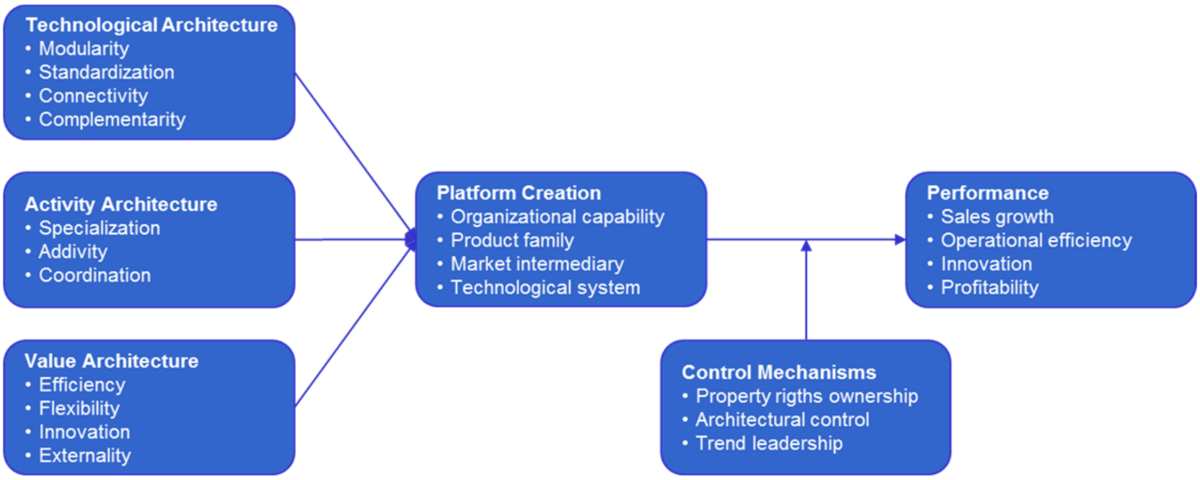

Table 1 – Overview of Platform Streams

Stream	**Organizational capabilities**	**Product family**	**Market intermediary**	**Technology system**
Platform variants	Platform organization; platform investment; platform technology	Product platform; internal platform; supply chain platform	Multi-sided platform; 2-sided platform	Industry platform; technology platform
Construct	Dynamic capability	Product family	Multi-sided market	Technology system
Description	Platform as organizational capabilities which 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 which 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; multi-sided markets	Network externalities; innovation; standards; modularity
Value Creation	Flexibility; Superior adaption	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
Main works	Kogut & Kulatilaka (1994) Ciborra (1996) Kim & Kogut (1996)	Meyer & Lehnerd (1997) Robertson & Ulrich (1998) Meyer & Utterback (1993)	Rochet & Tirole (2003) Caillaud & Jullien (2003) Armstrong (2006) Rochet & Tirole (2006)	Gawer & Cusumano (2002) Bresnahan & Greenstein (1999) West (2003) Gawer & Henderson (2007)

Table 2 – Architectural Leverage

Stream	**Organizational capability**	**Product family**	**Market intermediary**	**Technology system**
Technological Architecture	Standardization; complementarity	Modularity; standardization; connectivity	Connectivity; complementarity	Modularity; standardization; connectivity; complementarity
Activity Architecture	Specialization	Specialization; addivity	Addivity; coordination	Specialization; addivity; coordination
Value Architecture	Flexibility	Efficiency; flexibility; innovation	Externality	Efficiency; flexibility; innovation; externality
Control Mechanisms	Trend leadership	Architectural control; property rights ownership	Trend leadership; property rights ownership	Property rights ownership; architectural control; trend leadership