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Platform Generativity: Complementor's Characterization of Software Platform Generativity

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Abstract – Recent years have seen emergence of platform as the dominant organizational form with firms competing as ecosystems of consumers, partners and suppliers.

The ability of firms to build multi-sided platform with ability to attract consumers and complementors is critical to growth and survival of the firms. These ecosystems are socio-technical systems where the properties of the underlying technical architecture combine with human-agency.

Digital platforms are "multisided digital frameworks that shape the terms on which participants interact with one another "(Kenney & Zysman, 2016) and by being intermediaries platforms depend on network effects.

Studies have identified generatively as the key driver of platform growth. Remneland-Wikhamn, Ljungberg, Bergquist, and Kuschel (2011) show that "it is generativity – not openness – that builds the aggregated value" and find generatively as significant to open and distributed innovation.

In this study we focus on the phenomenon of generativity as viewed by the complementors in a platform context as part of this study.

We develop research prepositions that form the basis for further empirical studies to develop the characteristics of the ecosystem architecture that are critical to achieve generativity

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INTRODUCTION

Recent years have seen emergence of platform-based firm as the dominant organizational form competing as ecosystem of customers, partners and suppliers. Firms with platform-based business model are among the most valuable brands as per the Interband (2016) Global Brand Rankings which includes Apple, Google, Amazon and Samsung ("Best Global Brands - 2016 (Interbrand) | Ranking The Brands", 2017). Similarly "all ten start-ups included in the list of the most trending start-ups in 2015 are, to a certain extent, based on platforms ("SpotRocket - Quantitative rankings of the world's hottest startups," 2015).

Kenney and Zysman (2016) highlight the extent of activities around platform when they state "San Francisco is now experiencing what may be its biggest gold rush yet, with investors, entrepreneurs, and data scientists working furiously to create 'disruptive' new businesses. For investors, inherently optimists, the question is how to build platforms, attract users, and then capture the value that is generated from the emerging ecosystem" (Kenney & Zysman, 2016)

Digital platforms are "multisided digital frameworks that shape the terms on which participants interact with one another "(Kenney & Zysman, 2016) and by being intermediaries platforms depend on network effects. Regardless of the actual services being offered by the platform most platform business models are based on monetizing "value creating user actions" such as searches (google), social interactions (Facebook) or brokering search for product and services (eBay, Uber, OLA). Market intermediary platforms reduce search and transaction costs (Rochet & Tirole, 2003).

Software platforms evolve through "voluntarist and spontaneous innovation" by "large, heterogeneous and uncoordinated crowd of people" (Zittarin, 2006) enabled by generative properties of the platform where Generativity is defined as the "ability of self-contained system to create, generate, or produce new content, structure, or behavior without additional help or input from the original creators" (Tilson et al., 2010). This generativity of platform architecture is the core properties that support evolutionary mechanisms of variation, selection and retention (Sandberg, 2014).

Studies have identified generativity as the key driver of platform growth. Remneland-Wikhamn, Ljungberg, Bergquist, and Kuschel (2011) show that "it is generativity – not openness – that builds the aggregated value" and find generatively as significant to open and distributed innovation.

The generativity phenomenon has in recent time been very visible in emergence and growth of mobile ecosystems around IOS and Android which now form a duopoly displacing all other mobile platforms.

In this paper we present a multi-perspective view of generativity and posit some of the factors that can be viewed as contributing to generativity in the context of a platform-based software ecosystems

In the next section we present the theoretical background and develop the potential research preposition that will form the basis for further empirical study on Generativity

THEORETICAL BACKGROUND

2.1 Platforms

Although there is no unified definition of platform in literature (Baldwin & Woodward, 2009; Sandberg, Holmstorm, & Lyytinen, 2013) a common design pattern is recognized among the various strands of platform research. Baldwin and Woodward (2009) define platform as "a set of stable components that support variety and resolvability in a system by constraining the linkages among the other components".

Schreieck et al. (2016) define platform as "foundational products, services, or technologies upon which additional complementary products, services or technologies can be developed (Gawer, 2009)"

Gawer and Cusumano (2008) define an industry platform as a foundational technology "essential for particular business ecosystem" and posit the participation of complementary products and innovations are essential for industry platform success." Industry platforms are at the core of ecosystem which revolves around such platforms.

Gawer (2009) defines multi-sided markets platforms as an "intermediary between activities and requirements for two or more groups of customers, either individual or companies who utilize the platform for transactions". In a multi sided market agents interact through a platform and impact each other through network externalities. Success of a multi-sided industry platform depends on number of users and externalities derived from network effects (Rochet & Tirole, 2003).

Reuse of core components, architectural partitioning of components into stability domains of stable core components and cross sectionally and longitudinally varying peripheral components and a set of standard design rules governing component relations (Baldwin & Woodward, 2009) are common set of features that all streams of research converge.

2.1.1. Digital Platforms

Digital platforms are "multisided digital frameworks that shape the terms on which participants interact with one another "(Kenney & Zysman, 2016) and by being intermediaries platforms depend on network effects. Regardless of the actual services being offered by the platform most platform business models are based on monetizing "value creating user actions" such as searches (google), social interactions (Facebook) or brokering search for product and services (eBay, Uber, OLA). Market intermediary platforms reduce search and transaction costs (Rochet & Tirole, 2003).

Five factors have been identified as impacting the size of platforms namely (a) indirect network effects; (b) scale economies;(c) congestion, (d) platform differentiation and (e) multihoming.

Indirect network effects arise as the attractiveness of the platform for users is related to the population of complements and the third party complementors are willing to participate if platform provides "sufficient incentives to fulfill developers' needs such as value appropriation or recognition (Benlian, Hilkert, & Hess, 2015; Rochet & Tirole, 2003)".

Congestion inhibits participations as the cost of search, promotion and niche creation becomes more difficult. The last two factors namely platform differentiation and multihoming are relevant when there are competing platforms (Evans & Schmalensee, 2007) and users decide to join a ecosystem

2.1.2 Platform Architecture

The key aspects of digital platforms are the existence of a shared set of relatively stable substrate of technologies, tools and interfaces accessible to complementors who can build,

distribute and monetize their innovations using platform provided resources. Platforms are also used as the foundation of other platforms e.g. Amazon Web Services is used to build tools and Facebook is both a social media platform and an application development platform.

Software platforms share the above characteristics and are defined as "the extensible codebase of a software-based system that provides core functionality shared by the modules that interoperate with it and the interfaces through which they interoperate" (Tiwana, Konsynski, & Bush, 2010). The "collection of the platform and the modules specific to that platform as that platform's ecosystem" (Tiwana et. al., 2010). The modules can be provided by heterogeneous set of complementors.

"The software ecosystem platform has the potential to attract new users, increase 'stickiness' (i.e. make it harder to change platform), accelerate innovation and provide sharing of development costs (Bosch, 2009)". Sandberg, Holmstorm, and Lyytinen (2013) Platform ecosystem combine the combinatorial innovation possibility through provision of complements and openness of the layered architecture that support evolution makes platform central to digital innovation (Yoo et al., 2012).

Digital platforms reflect the layered modular architecture of the digital artifacts. Modular architecture represents a reductionist view where the modules are derived by mapping the product functionality to components and is fixed early in the product lifecycle. Modular architecture is widely used to build variability in the product architectures while a layered modular architecture enables convergence and generativity. Convergence brings previously disparate user experiences together such as triple play, create smart products with emergent uses and can disrupt industry boundaries. Combination of generativity with convergence allows digital products to allow changes by complementors thereby acting as platform leading to the emergence of digital platform as the primary organizing logic.

2.2 Generativity

Generativity can be seen as be belonging to a class of phenomenon viewed as originating from the work in socio-technical systems and complex system studies where it is posited that "observed complexity of a phenomenon such as biological diversity, social systems and language can be traced back to some basic elements and their mechanisms for interaction" (Bygstd, 2015). However, Zittarin's law review article in 2006 and subsequently his 2008 book on the subject of generativity can be seen as foundational to the introduction of concept to IS research.

Zittrain (2006) defines generativity as "a technology's overall capacity to produce unprompted change driven by large, varied, and uncoordinated audiences" which he modifies in his subsequent book to read "is a system's capacity to produce unanticipated change through unfiltered contributions from broad and varied audiences" (Zittrain, 2008). The redefinition highlights the extension of the concept from referring to the properties of a technology to that of a system thus including human actors in addition to the technology. It also recognizes audiences as contributors and recognizes the ability of the participants to modify the system thus explicating the mutability of the system (Woodard & Clemons, 2014)

Focusing on the technological components of the generative system Zittrain (2008) identifies five characteristics that underlie the generativity of the technological system. These factors are

1. Leverage: captures the ability of a technology to improve the performance of the actors using the system e.g. using a mapping service to navigate provide leverage over those using paper maps

2. Adaptability: refers to the malleability of the system to adjust to the demands of the context or the demands of the task

3. Ease of Mastery or the ease with which the participants can exploit the full potential of the system. The parameter may also relate to the prior knowledge required to use the system e.g., a system modifiable by using a generic programming language is more generative than a system requiring a specialized language

4. Accessibility refers to the barriers to initial use of technology or how easy it is for ordinary users e.g., a technology that requires an initial toolkit cost to engage with is less accessible than a technology that does not require such toolkit

5. Transferability refers to the ease with which changes in technology are propagated among the users of technology e.g., open-source software has higher transferability than a commercial product.

Any digital artifact which processes above five characteristics is generative as it allows unfiltered participation of heterogeneous and distributed set of actors that produce more unanticipated changes in the system.

Generativity therefore refers to how innovation is influenced by the characteristics and arrangement of technological infrastructure which invites new usage.

The concept of generativity in IS research refers to recognition of emergence as a characteristic of digital objects or what Kallinikos, Aaltonen, and Marton (2013) refer as "ambivalent ontology as they are objects, but lack plenitude and stability afforded by traditional items and devices".

2.2.1 Generative Properties

Yoo et al. (2010) identify the three characteristics of digital artifacts namely (a.) Reprogrammability, (b.) Homogenization of data and (c.) Self-referential nature of digital technology as contributing to the emergence of layered modular architecture a hybrid of the modular architecture from the world of physical architecture and layered architecture of the digital products "where the degree by which the layered architecture adds the generativity to the modular architecture forms a continuum" (Yoo et al., 2010). The layered modular architecture enhances generativity by enabling innovations in any layer to cascades to the other layer and are combined into loosely coupled assemblages in unanticipated ways (Yoo et al., 2010).

2.2.2 Generativity as Evolution

Tilson et al. (2010) describe the emergence of unbound digital infrastructures "built on the notion that they are never fully complete, that they have many uses yet to be conceived of, and that the public and ordinary organizational members can be trusted to invent and share good uses" (Zittrain, 2008) as a consequence of generativity of digital innovation.

Generativity is viewed as a socio-technical phenomenon and a consequence of system evolution (Eck & Uebernickel, 2016). This perspective privileges interaction among actors and artifacts as causals to evolutionary dynamics that produce unanticipated change e.g. Bygstad (2015) defines generativity as "ability of technical and social elements to interact and recombine to produce new solutions"

Software platforms evolve through "voluntarist and spontaneous innovation" by "large, heterogeneous and uncoordinated crowd of people" (Zittarin, 2006) enabled by generative properties of the platform where Generativity is defined as the "ability of self-contained system to create, generate, or produce new content, structure, or behavior without additional help or input from the original creators" (Tilson, Lyytinen, & Sørensen, 2010). This generativity of platform architecture is the core property that support evolutionary mechanisms of variation, selection and retention (Sandberg, 2014)

The generatively of the platform is theorized as being related to the "loose coupling" among the platform component which "promote a new stretch-fit patterns between increased technology variability and its alignment with use contexts and calls for constant changes in firm's strategy and economic logic" (Sandberg et al., 2013).

2.2.3 Social Generativity

Avital and Te'eni (2009) explore how information technology-can supports generative capacity in people. They define generativity as "a capacity for rejuvenation, a capacity to produce infinite possibilities or configurations, a capacity to challenge the status quo and think out-of-the-box, a capacity to reconstruct social reality and consequent action and a capacity to revitalize our epistemic stance".

Avital and Te'eni (2009) postulate the idea of 'generative fit' of information system to refer to the extent in which "particular Information technology artefact, or part thereof, is conducive to evoking and enhancing that generative capacity in people" where generative capacity is the attribute of a person and refers to the "ability to reframe reality and subsequently to produce something ingenious or at least new in a particular context" (Avital & Te'eni, 2009)

They identify characteristics of being evocative, being adaptive and being open-ended as fundamental to generative design

1. Evocative as the system enables users to translate their ideas to new contexts by creating environment or conditions that stimulate insights. Some characteristics that make systems evocative include visualization, simulation, abstraction, integration and communication

2. Adaptive to usage by diverse set of users and has application in diverse problem spaces, is easy to understand and easy to master. Two major characteristic that improve system adaptability are customization and automation

3. Open Ended in being "able to generate a virtually infinite number of configurations by heterogeneous users" (Avital & Te'Eni, 2009). Open endedness can enhance regeneration and future configuration. The property recognizes the contribution by independent third-party peers as well as the evolution of the information system. Open endedness is enhanced through support for peer production and modularity of the system

The generative fit idea is to evaluate the evocativeness, adaptive capacity and open endedness and match to the informational needs of task

CONCEPTUAL MODEL

In the conceptual model proposed in this paper we consider generativity as a socio-technical phenomenon and we consider generativity as aggregative impact of three dimensions of generativity. We refer to three dimensions as

1. Generative Properties Perspective which refers to the perspective which views generativity as a consequence of inherent properties of digital artifacts, system design, architecture and governance practices that affect the participation of the complementors.

2. Generative Evolution Perspective which views generativity as arising because of the human agency. The perspective posits generativity to arise out of localized interaction of participants with artifacts in the ecosystem and diffusion through the ecosystem through complex interactions among the participants of the ecosystem in their localized contexts e.g. interaction of the users with the platorm and diffusion of the innovation through complex interactions based of localized innovations to the wider ecosystem

3. Generative Relationship perspective regards generativity as primarily arising out of the relationship between participants of the ecosystem. when they are characterized by directedness and allow an architecture of participation that supports the action potential of participants in the ecosystem

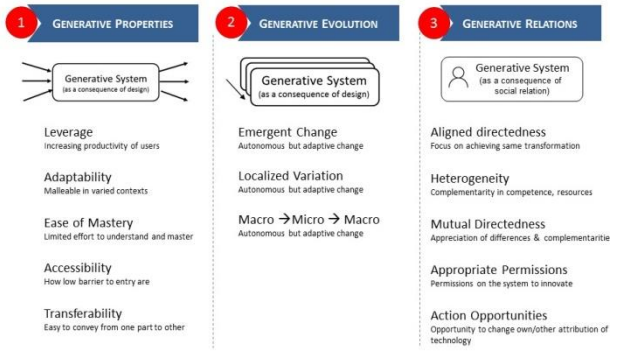

Figure1. **Three perspectives on generativity. Adapted from "Untangling generativity: Two perspectives on unanticipated change produced by diverse actors" by A. Eck, & F. Uebernickel, 2016 *Proceedings of the 24th ECIS*. Istanbul: Boğaziçi University. Copyright (2016) ECIS**

RESERCH

Success of platform-based software ecosystems is driven largely by generatively of the platform as attracting both developers and users are key challenges for this type of platform. This research has a sociotechnical focus and includes impact of architecture, governance and contextual dynamics and emergent organizational forms (Tiwana, 2010).

A technical perspective posits that generativity of the platform arises out of the platform architecture, openness to contribution by complementors and the boundary resources such as API and SDKs (Benlian, Hilkert, & Hess, 2015; Bygstad, 2015; Yoo, 2010).

The socio-technical view of generativity posits that it is not merely the properties of the platform architecture or design, but the accessibility of the platform resources determined by governance and control mechanisms (Eaton, 2012) to a heterogeneous group of complementors that drives innovations as these agents deploy their varied capabilities (Boland, Lyytinen, & Yoo, 2007). The evolutionary dynamics are theorized to result from knock off effect of localized change (Eck & Uebernickel, 2016) in localized contexts.

The need therefore exists to develop theoretical studies that allow complementors to evaluate generativity of an ecosystem as predictor of their potential success on the platform and for the platform providers to create technical, diffusional and social structures that support generativity.

The planned study is a response to this need and explores the concept from the perspective of a complementor to investigate the question of

What characterizes generativity in ecosystem as perceived by complementors?

3.1 Research Prepositions

In our study we aim to investigate the impact of the dominant platform architecture of the software ecosystem as exemplified by Android ecosystem one of two dominant mobile platforms.

Based on a thematic survey of the platform literature we postulate the important architectural dimensions that impact Generativity to include (a.) Openness (Benlian et. al, 2015; Anvaari and Jansen, 2015) (b) Control Mechanism (Tiwana, 2015; Tiwana and Kiel, 2009) and (c.) Boundary resources (Ghazawhneh & Henfridsson, 2013).

3.1.1 Openness

A platform is considered open "to the extent that: 1) no restrictions are placed on participation in its development, commercialization or use; or 2) any restrictions …are reasonable and non-discriminatory, that is, they are applied uniformly to all potential platform participants".

Openness has a paradoxical impact on the generativity of the platform as opening the platform to external developer's increases diversity of complementors and innovation (Tiwana, 2013). However, this can lead to overcrowding, increases coordination effort for the platform provider and loss of control on platform direction as complementors add diverse applications to the ecosystem. (Benlian et al., 2015). We therefore postulate.

Research Preposition 1: Openness of platforms is positively related to the generativity through free market contribution from third party complementors

Research Preposition 2: Openness of platform can negatively impact generativity if the openness leads to overcrowding

3.1.2 Control Mechanism

Fisher (1995) describes the purpose of control "to create conditions that motivate the organization to achieve desirable or predetermined outcomes". Control mechanisms help platform providers to establish norms that balance the needs of platform provider with the needs of the complementors (Tiwana, 2015). Tiwana also provides a typology for control mechanisms which we use to posit the ipact of control mechanisms on te platform

Tiwana (2015) defines input control as "the degree to which a platform owner adjudicates allowing revisions of an extension into the ecosystem". Input control typically involves admission control through application of screening criteria

Behavioral control involves "explicitly specifying the appropriate behaviour (e.g., development methodology, internal testing guideline) that can be observed and evaluated by the dominant partner" Mukhopadhyay et al. (2016), but is typically difficult to enforce in platform setting with a large number of complementors

Output control involves the evaluation of the performance of task result and not the process (Tiwana & Keil, 2009). Outcome may include metrices that refer to the classic software parameters such as cost, schedule or quality of outcome and requires pre-specification of requisite achievement levels.

Research Preposition 3: Use of input controls to ensure quality of complements leads to higher generativity

Research Preposition 4: Use of output controls enhance generativity by ensuring outcomes optimal for the ecosystem health

Research Preposition 5: Use of behavioral controls improves generativity through ensuring interactions between complementors are generative with appropriate action potential

3.1.3 Boundary Resources

Boundary resources refers to the "software tools and regulations that serve as the interface for the arm's-length relationship between the platform owner and application developer" (Ghazawneh & Henfridsson, 2013). Boundary resources are a mean to transfer design capability to the users (Von Hippel & Katz, 2002) and are also the locus of control implementation in the ecosystem. The boundary resources are therefore critical to generativity and to the establishment of balance across paradoxes of stability and change.

Research Preposition 6: Complexity of development boundary resources decreases generatively.

Research Preposition 7: The increase in breadth of scope coverage by technical, developer and social boundary resources can improve the generativity of the platform

Research Preposition 8: The ease of mastery of boundary resources enhances the generativity of the platform

The table below summarizes the research prepositions that we propose to explore further in the study

Table 3.1

Research Prepositions

Research Preposition 1	Openness of platforms is positively related to the generativity as it encourages free market contribution from third party complementors
Research Preposition 2	Openness of platform can negatively impact generativity if the openness leads to overcrowding
Research Preposition 3	Use of input controls to ensure quality of complements leads to higher generativity
Research Preposition 4	Use of output controls enhance generativity by ensuring outcomes optimal for the ecosystem health
Research Preposition 5	Use of behavioral controls improves generativity through ensuring interactions between complementors are generative with appropriate action potential
Research Preposition 6	Complexity of development boundary resources decreases generativity
Research Preposition 7	The increase in breadth of scope coverage by technical, developer and social boundary resources

	can improve the generativity of the platform
Research Preposition 8	The ease of mastery enhances generativity of the platform

FURTHER STUDY

We propose to empirically study the phenomenon of Generativity in software ecosystems to develop a conceptual model to identify contributors to the development of Generativity

An area that has witnessed rapid growth largely through the contribution of independent developers is the mobile platforms of Android and iPhone. Have in the recent years experienced rapid growth, have been locus of application ecosystem with heterogeneous complementors, have demonstrable network externalities and have experienced intense competition with high fatality rates. We therefore propose to use Android as an exemplar ecosystem for the purpose of the study

This research design of this study is based on the theory building nature of the research question designed to examine socio-technical phenomenon of Generativity as experienced by developers. We adopt a realist ontological position while using a constructivist epistemology considering the platform ecosystem as representing the external reality while the nature of generativity phenomenon involves human intentionality and is examined from a lived experience perspective.

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