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Emergent equifinality: An empirical analysis of ecosystem creation processes

Llewellyn D. W. Thomas
Imperial College London
Imperial College Business School
l.thomas09@imperial.ac.uk

Erkko Autio
Imperial College Business School
Innovation & Entrepreneurship
e.autio@imperial.ac.uk

Abstract

Although industrial organization is increasingly trending towards ecosystem competition, little is known about the processes of ecosystem emergence. We apply institutional theory, event colligation and optimal matching to extract and compare sequences of four types of activities ? re-source, technological, institutional and contextual ? in six successful ecosystem creation cases: Amazon, eBay, Facebook, Google, Salesforce, and Wikipedia. We show that although the emergence process of each ecosystem is unique, there are three common phases of emergence ? Initiation, Momentum, and Optimization. Path dependency and equifinality are then demonstrated through decreasing cross-subject similarities for each successive phase.

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ABSTRACT

Although industrial organization is increasingly trending towards ecosystem competition, little is known about the processes of ecosystem emergence. We apply institutional theory, event colligation and optimal matching to extract and compare sequences of four types of activities – resource, technological, institutional and contextual – in six successful ecosystem creation cases: Amazon, eBay, Facebook, Google, Salesforce, and Wikipedia. We show that although the emergence process of each ecosystem is unique, there are three common phases of emergence – Initiation, Momentum, and Optimization. Path dependency and equifinality are then demonstrated through decreasing cross-subject similarities for each successive phase.

INTRODUCTION

As the examples of IBM in the 1980s and Nokia in the 2000s both demonstrate, the successful introduction of ecosystems can rapidly undermine apparently unassailable positions in seemingly matured and settled industries. With the continuous diffusion of ICT technologies across industry sectors and the associated spread in the use of 'platform strategies' (Gawer & Cusumano, 2002, 2008), managerial attention is increasingly focusing on 'business ecosystems' or 'innovation ecosystems' (Adner, 2006; Iansiti & Levien, 2004b; Moore, 1993). Reflecting this uptake in managerial attention, research attention also seems to be increasing (see for instance Adner, 2012; Adner & Kapoor, 2010; Baldwin, 2012; Gulati, Puranam, & Tushman, 2012; Nambisan & Sawhney, 2011; Tiwana, Konysnski, & Bush, 2010). Thus far, most of the ecosystem literature has focused on understanding the structure and dynamics of *already existing* innovation ecosystems, with research attention focused on issues such as value co-creation and value appropriation in ecosystem contexts (Adner & Kapoor, 2010; Gawer & Cusumano, 2002; Jacobides, Knudsen, & Augier, 2006).

Much less attention has been attached to the *creation* of ecosystems, however. Although the early ecosystem literature proposes a four stage model of an ecosystem lifecycle (Moore, 1993) and more recently Gawer (2009) suggests an evolutionary typology of platform leadership, neither specifically examines the processes underlying ecosystem emergence. Two literatures appear to offer useful insight to address this issue. The industrial economics literature offers insights into participant adoption strategies in multi-sided market contexts (Eisenmann, 2008; Eisenmann, Parker, & Van Alstyne, 2006; Hagiu & Eisenmann, 2007), and the alliance formation literature offers insights into the social context of prior alliances and interdependence (Gulati, 1995; Gulati & Gargiulo, 1999). However, although these literatures provide valuable insight, they do not specifically consider the creation *processes* of ecosystems.

The lack of research on ecosystem emergence represents an important gap, given that many organizations, particularly in ICT sectors, today explicitly seek to create ecosystems and drive these to their advantage. As value creation processes become increasingly intertwined in today's highly specialized industrial landscape, it is important to start considering how ecosystems are created in the first place, what activities and dynamics characterize ecosystem emergence and evolution, and under which conditions could ecosystem innovators stand a realistic prospect of achieving success (Ozcan & Eisenhardt, 2009). This paper seeks to contribute insight on two important issues in this area: *First, what are the underlying drivers of ecosystem emergence; and, second, do ecosystem emergence processes exhibit similarities across cases?* Providing insight into these questions is important not only for ecosystem theory, but also, for managerial practice, as industry incumbents seek to promote and facilitate ecosystem creation to gain strategic edge over rivals.

Any investigation of ecosystem emergence necessarily needs to focus on a variety of different mechanisms. For instance, when an ecosystem has a platform that acts as its locus of coordination, the platform technological features are likely to exercise an important influence on ecosystem evolution (Gawer & Cusumano, 2002; Iansiti & Levien, 2004a; Thomas, Autio, & Gann, 2012). In addition, the dependencies between the ecosystem participants exercise an important influence on coordination success and resource mobilization (Adner & Kapoor, 2010). Similarly, the variety of complementary asset providers and consumers that participate in the ecosystem exercise an influence on membership, resource mobilization and support mechanisms (Gawer & Cusumano, 2002; Gulati et al., 2012; Iansiti & Levien, 2004a; Wade, 1995). Finally, cognitive processes such as legitimacy creation, trust building and the creation and manipulation of meanings also represent important challenges to ecosystem governance (Agerfalk & Fitzgerald, 2008; Gawer & Cusumano, 2002; Iansiti & Levien, 2004a), as ecosystem participants work to develop the hierarchies and rules which govern their interactions.

In this paper, we pioneer an institutional approach to understanding ecosystem emergence. Specifically, we integrate insights from dominant design theory, institutional entrepreneurship theory, and social movement theory to provide theoretical grounding for our empirical study (Van De Ven & Hargrave, 2004). We suggest a three-stage model of ecosystem emergence – Initiation, Momentum and Optimization – and that the processes of ecosystems creation are unique to each ecosystem. In addition path dependency and equifinality in ecosystem emergence are demonstrated through decreasing cross-subject similarities with each successive phase.

This paper is structured as follows. The first section introduces the institutional approach to ecosystem emergence and, integrating dominant design theory, social movement theory and institutional entrepreneurship theory, identifies four creation activities – namely, resource, technological, institutional and context activities. The second section introduces the research setting – digital services – and outlines the six research cases. The third section outlines the research methodology and the fourth section an exposition of the results. The fifth section then discusses the results in the context of our extant understanding of institution formation and change.

THEORY

In management research, the term 'ecosystem' has been usually used to refer to a network of interconnected organizations that are linked to or operate around a focal firm or a platform (Adner, 2006; Adner & Kapoor, 2010; Iansiti & Levien, 2004a; Moore, 1993, 1996; Teece, 2007). The difference between the ecosystem construct with other network constructs in management research is that business ecosystems comprise both production side and use side participants, including suppliers, complementors, customers, competitors, research institutions, regulators, judiciary and standard setting bodies (Autio & Thomas, forthcoming; Iansiti & Levien, 2004a; Teece, 2007). Following Autio & Thomas (forthcoming), we define an ecosystem as *a network of interconnected organizations, organized around a focal firm or a platform, which incorporates both production and use side participants, and focuses on the co-creation of new value through innovation*.

Given that ecosystems comprise multiple participants who need to coordinate their actions, an institutional theory perspective provides a potentially useful framework to understand the evolution of ecosystems.[1] Structurally, the notion of ecosystems resonates closely with the notion of institutional fields in institutional theory, with both comprising suppliers, complementors, customers, competitors, universities, regulators, judiciary, and standard setting bodies (DiMaggio & Powell, 1983; Iansiti & Levien, 2004a; Scott, 2008; Teece, 2007). An institutional field is the set of organizations that constitute a recognized area of life, characterized by structured network relations, and that share a set of institutions (Lawrence & Phillips, 2004). Both institutional fields and ecosystems cut across traditional industry boundaries and are defined by activities within which groups of organizations participate. Ecosystem structures represent an institutional arrangement among distinct but related organizations

[1] By introducing an institutional theory perspective to ecosystems research, we are not necessarily arguing that an ecosystem is an institution in the context of wider society, although in some cases this is indeed be the case – consider the iconic status of Apple Inc.

characterized by often close network interactions, a certain degree of reflexivity, and a logic of mutual exchange that operates differently from that of markets and hierarchies (Sydow & Windeler, 1998). Given these similarities, we use an institutional theory lens to understand the evolving participant structure, logics, and governance structures of ecosystems (Scott, 2008).

From the perspective of understanding the major challenges involved in ecosystem creation and facilitation, perhaps the most salient aspect of ecosystems is their governance. Although ecosystem participants are bound by complex relations that often involve mutual interdependence, they are not part of the same hierarchy. This means that incumbents cannot simply command ecosystem participants to invest in desired developments and then control that commands are followed. Instead, ecosystem creation and facilitation has to employ informal governance mechanisms such as trust, legitimacy, and leadership. Legitimacy has been considered but not explicitly developed within the ecosystem literature. Iansiti and Levien (2004a) underlined the importance of legitimacy and trust in relation to ecosystem operations and others have acknowledged the importance of openness, trust, tact and professionalism in developing an ecosystem (Agerfalk & Fitzgerald, 2008). The concept of 'platform leadership' (Gawer & Cusumano, 2002) implies legitimacy through its focus on leadership – a hub firm cannot lead an ecosystem without being seen as legitimate by partners and other ecosystem participants (Olleros, 2008; Sivadas & Dwyer, 2000). To effectively facilitate ecosystems, therefore, hub firms need to gain social acceptability and legitimacy in order to gain a leadership position within the ecosystem (Adner & Snow, 2010).

Three institutionally oriented theoretical approaches suggest themselves as pertinent for our consideration (Van De Ven & Hargrave, 2004). The first is the dominant design theory, which provides a theoretical logic to predicate that technological characteristics of an ecosystem are rarely determined on technological grounds alone but instead are socially and institutionally constructed (Kaplan & Tripsas, 2008; Tushman & Murmann, 1998; Tushman & Rosenkopf, 1992; Van De Ven & Garud, 1993). In particular, dominant design theory provides insight into the technological design, delivery and operation of the product(s) or service(s) around which the ecosystem is organized. A second theoretical approach is that of social movement theory, which provides the means to understand the actions of ecosystem participants through the development of opportunity structures, mobilizing structures and framing processes (Davis & McAdam, 2000; McAdam & Scott, 2005). In particular, the social movement theory provides insight into the collective actions of ecosystem participants and the effect on both the ecosystem and the environment in which the ecosystem resides. The third theoretical approach is that of institutional entrepreneurship (DiMaggio, 1988; Garud, Jain, & Kumaraswamy, 2002), which enables specific consideration of the actions of the hub firm that provides the digital service in developing the ecosystem. Institutional entrepreneurship theory provides insight into the discursive and legitimation processes that occur in institutional formation.

Broadly stated, dominant design theory considers the activities concerned with the technological development of the platform; social movement theory considers the collective activities of the ecosystem participants; and institutional entrepreneurship theory considers activities undertaken taken by the hub firm. Taken together, these three frameworks suggest that there are four types of activities that drive the emergence of ecosystems – resource activities, technological activities, institutional activities and contextual activities.

Resource activities

Resource activities refer to those concerned with the procurement and management of resources by the hub firm. Salient resource activities include corporate activities, financial activities, coalition building activities and competence building activities.

An important early resource is the organizational form, and the structure and processes of the initiating hub firm (Zald & Ash, 1966). As such those activities involved in the establishment and maintenance of the organizational form are important in its success. A related activity is the adoption of other organizational forms or technologies. The acquisitions or investment in complementary asset providers can develop the ecosystem by appropriating existing organizational forms and restructure them into something more appropriate (Davis & McAdam, 2000; McAdam, Tarrow, & Tilly, 2001). Alternatively, investment in an organization others can be encourage to participate (Garud et al., 2002) or encourage important stakeholders to favor the ecosystem (Battilana, Leca, & Boxenbaum, 2009).

Another important resource activity is the acquisition of financial resources, such as initial seed investments, venture capital investments, loans, IPOs and stock issuance. Financial resources are important as sufficient resources are required in order for an ecosystem to be created (DiMaggio, 1988; Schilling, 2009; Smith, 1996). For instance, financial assets can be used during early stages to bypass sanctions likely to be imposed by opponents of the change (Greenwood, Suddaby, & Hinings, 2002), or ride out the negative costs of the transitional period during which the new digital service and related ideas are likely to be unknown (Greenwood & Suddaby, 2006). Financial assets are also useful to bring others into the coalition, such as by providing a service or product for free as distinct to the charged offering of the incumbent (Garud et al., 2002).

A further resource activity is establishment and maintenance of coalitions, such as joint ventures, strategic agreements, licensing, and marketing and technology agreements (Cusumano, Mylonadis, & Rosenbloom, 1992; Khazam & Mowery, 1994; Smith, 1996; Soh, 2010; Suarez, 2004). Ecosystem success springs not just from technological superiority, but also from the level of organizational support from the surrounding technological community, such as coalitions (Wade, 1995). These linkages represent the interdependencies between the participants in the ecosystem (Adner & Kapoor, 2010; Iansiti & Levien, 2004a), and can be between individual actors, and at other times between multiple individual actors, such as consortia, trade associations, and so on (Rosenkopf & Tushman, 1994).

Another important resource activity is the acquisition of appropriate skills and competences. Both production capacities and marketing capabilities are vital resources that will influence the emergence of an ecosystem (Hariharan & Prahalad, 1991; Schilling, 2009; Smith, 1996). Strong organizational linking capabilities are also required to develop partnerships and alliances (Tushman & Murmann, 1998). Learning capabilities, both within and between organizations (Lee, O'Neal, Pruett, & Thomas, 1995), and of the market (Hariharan & Prahalad, 1991), are vital. Learning-curve advantages can result in more efficient and effective technology (Schilling, 2009).

Technological activities

A second set of activities are those related to the design and provision of the underlying technologies. Salient technological activities include the design and delivery of the underlying technologies, the establishment and operation of supporting services for ecosystem participants, and the management of ecosystem membership.

The design and functionality of the core platform are an important technological activity. Technological design can often be the key factor in successful emergence (Abernathy & Utterback, 1978; Christensen, Suarez, & Utterback, 1998; Murmann & Frenken, 2006; Suarez & Utterback, 1995), although others have noted that the characteristics of the technology only have an strong influence (Schilling, 2009). When a technology or offering is superior to competing technologies on the dimension of merit, all other things being equal, it will likely succeed over others (Suarez, 2004). Similarly, Gawer & Cusumano (2002) noted that technological design has a strong influence on platform and ecosystem success. Related technological activities include those day-to-day routines that facilitate the operation of the platform. For instance, digital service availability – whether the system is down or running slow – is vital.

The supporting services that enable ecosystem participants to enhance their performance, such as toolkits, support programs and training, are also an important technological activity. By easing the burden of joining the ecosystem, participants can be motivated and subsequently provide legitimacy through their provision of resources (DiMaggio, 1988). The maintenance of group communications, the development of formal alliance programs, and the involvement of users in testing, and the development linkages with educational curricula (Aldrich & Fiol, 1994; Lawrence & Suddaby, 2006) are serve as useful mobilization mechanisms in ecosystem contexts.

A final technological activity is the management of ecosystem membership through technological means, such as allowing opening to new members or restricting the entry of others. Ecosystems encompass many members, and the criteria for membership is an important instrumental activity (Gulati et al., 2012). Membership strategies, such as those that involve the definition of the rules of membership and their meaning for an institutional community, are also important in driving legitimacy (Lawrence, 1999; McCarthy & Wolfson, 1996), as well as enabling collaboration activities

(Phillips, Lawrence, & Hardy, 2000). These activities can also have important impact on the stability of the ecosystem (Zietsma & Lawrence, 2010).

Institutional activities

A third set of activities are those related to the structure and operation of the ecosystem, as distinct to the functional and delivery activities outline above. These activities are internal to the ecosystem and include actions by both the hub firm and ecosystem participants. Salient institutional activities include rule-making and enforcement, discourse, and identity construction.

The first institutional activity relates to the establishment and application of rules, including those efforts to establish norms of behavior and procedures within the ecosystem. The rules of engagement, such as coordination, behavior and operation, have implications for the ability of ecosystem participants to influence the success of the ecosystem (Garud & Rappa, 1994; Suarez, 2004). In addition, rules and activities around governance are also an important mechanism for manipulating ecosystem dynamics and the right of the hub firm to control existing and future processes (Hinings, Greenwood, Reay, & Suddaby, 2004). Rule-setting activity also includes pricing, which can be varied in order to encourage adoption (Armstrong, 2006; Eisenmann et al., 2006; Murmann & Frenken, 2006; Rochet & Tirole, 2004; Suarez, 2004). A more tangible activity is the establishment of technical, legal or market standards that define "normal" processes involved in the production of a good or a service (Aldrich & Fiol, 1994; Lawrence, 1999). These standardization processes are inherently fragile, and both social and political skill needs to be deployed (Garud et al., 2002).

A second institutional activity relates to discourse. Discursive activities are those activities and practices such as writing and talking about the ecosystem, and consists of the motivating and convincing of others to accept and participate in the ecosystem (Battilana et al., 2009; Phillips, Lawrence, & Hardy, 2004). Active, sometimes controversial, discourse is essential for the hub firm to validate their role in the center of emerging ecosystem and to provide legitimacy (Aldrich & Fiol, 1994; Munir & Phillips, 2005; Phillips et al., 2004; Suddaby & Greenwood, 2005). In addition, discursive activity is complemented by intense sensemaking, experimentation and search for good practices as participants seek to adopt, adapt and utilize the new technologies in the emerging ecosystem (Garud & Rappa, 1994; Kaplan & Murray, 2010; Kaplan & Tripsas, 2008; Tushman & Rosenkopf, 1992).

Shared narratives, rhetoric and analogies, through white papers, speeches and attendance at conferences, shape participants' shared understanding of the ecosystem (Etzion & Ferraro, 2010; Suddaby & Greenwood, 2005; Zilber, 2007), as do promotional and sales activities set expectations and encourage participation in the ecosystem (Suarez, 2004). Actions that draw attention to the meaning of an object that goes beyond its functional use are also vital to drawing participants to the ecosystem (Zott & Huy, 2007).

A final institutional activity relates to the identity of the participants, in particular the construction of an ecosystem-level identity (Creed, Scully, & Austin, 2002). Often a collective identity – defined as an individual's cognitive, moral and emotional connection with a broader community, category, practice or institution (Polletta & Jasper, 2001) – can emerge in ecosystem contexts. A collective identity emerges through framing processes (Klandermans, 1992), and increases the ability of an ecosystem to mobilize (Davis & Thompson, 1995; Polletta & Jasper, 2001). Legitimating accounts are also intertwined with the construction of social identities, both legitimating participation and mobilizing others and crucial audiences. A further source of collective identity are those activities that develop amongst the participants, such as specific routines and practices (Polletta & Jasper, 2001). These routines can be seen to represent the emergence of a new institutional identity (Barley & Tolbert, 1997; Hinings et al., 2004).

Context activities

The final set of activities relate to the actors external to the ecosystem which have an impact on the creation processes of the ecosystem. Salient activities here include the actions of regulators and government, discourse in the press and wider society, and the actions of competitors.

Regulatory activities relate to those regulatory events that occur in the wider context, such as the passing of statutes that relate to the operation of the ecosystem and investigation by regulatory bodies. Governments may have a strong interest in the activities of the ecosystem and hence may regulate (Anderson & Tushman, 1990; Lee et al., 1995; Suarez, 2004; Tushman & Rosenkopf, 1992). By the act of regulating an activity, a government or regulator can not only (de)legitimate the ecosystem, it may also make the market much more (less) favorable (Sine, David, & Mitsuhashi, 2007). In particular they can change the regime of appropriability that governs the ability to capture profits

(Hariharan & Prahalad, 1991; Lee et al., 1995; Suarez, 2004; Teece, 1986). A related factor that influences the creation of ecosystem is institutional intervention, such as government purchases of a product (Suarez, 2004) or through a large and powerful users requesting a particular product design (Tushman & Rosenkopf, 1992). In these circumstances the sheer volume of production required for that user will be sufficient to ensure success through scale economies or through legitimacy signals. Similarly private institutions such as industry associations or standards making bodies can influence which technology can enter the market first (Suarez, 2004; Tushman & Rosenkopf, 1992).

The second context activity relates to the discursive actions of the press, analysts and other actors in wider society. Press activities include any written or spoken actions that discuss the ecosystem in a substantive manner (Phillips et al., 2004). Societal discursive activities are the dialogue that occurs in wider society, such as entering the general lexicon, referencing in art, winning awards, and the release books, magazines, academic or medical research that addresses the ecosystem. These activities have the effect of legitimating the ecosystem (Phillips et al., 2004), as can winning a certification competition which highlights the ‘best’ service or product (Rao, 1994). Signals of leadership are also important in the construction of markets and the shaping of boundaries (Santos & Eisenhardt, 2009), as they build legitimacy both for ecosystem participants and within wider society.

The final context activity considers the actions of competitors to the ecosystem, as successful ecosystems and hub firms will generate spin-offs and competing organizations (Fligstein, 2001; Rao, Morrill, & Zald, 2000). At times the contest between the ecosystem and competitors will focus on meaning construction (Benford & Snow, 2000; Ryan, 1991) and at other times related more directly to the core product or service, such as through price wars or functional improvements (Garud et al., 2002).

METHODOLOGY

The research setting for the study is digital services. Digital services are an attractive setting for studying the creation of ecosystems as digital services are generally not necessary consumed directly or alone, but instead are consumed by other services or jointly consumed. This is due to the fact that many digital services are designed as incomplete systems (Garud, Jain, & Tuertscher, 2008), necessitating their inclusion in a network, or ecosystem, of other complementary services. It is through the ecosystem that the combination of digital services provide the required utility to the ultimate economic entity that consumes the service. This is enabled by "loosely coupled" integration methodologies, with "just-sufficient" protocols of interoperability and extensibility, which are a good design for widely distributed systems and networks (Orton & Weick, 1990). Digital services also exhibit many of the characteristics of a high velocity environment, in that there are rapid changes in demand, competition, and technology (Bourgeois & Eisenhardt, 1988). In essence, digital services provide an ideal setting to observe the creation processes as they happen over shorter timescales than in other environments. For clarity digital services are defined as *informational resources available for consumption where the consumers do not own the physical or informational infrastructure*.

Six successful ecosystem emergence processes are investigated – Amazon, eBay, Facebook, Google, Salesforce, Wikipedia – which together illuminate the phenomenon of interest and cover a range of polar types (Pettigrew, 1990; Yin, 1984). Amazon is an online retailer, eBay an online auction service, Facebook a social networking service, Google a search engine, Salesforce an online customer relationship management service, and Wikipedia an open source encyclopedia. See Table 1 for an overview of each subject.

[Insert Table 1 around here]

An important differentiator for these digital services is that each has a different business model, and in doing so they exemplify the main digital service business models. Put succinctly, Amazon has a retail based business model; eBay a business model that is brokerage based; Facebook has a business model that is predominantly based upon social advertising; Google's business model is based on search-driven advertising; Salesforce.com has a subscription driven business model; and Wikipedia is open source, relying on its community and donations. A second differentiator is the types of participants within each ecosystem; Amazon is business to consumer service, while the services of eBay and Wikipedia link consumers to other consumers. Facebook and Google link businesses to consumers through advertising (and Facebook consumers to consumers for socially motivated reasons) and Salesforce is a business to business service. In addition, these six subjects vary by other important factors, including the effect of the dot-com crash, major crisis events, ecosystem participants, founder backgrounds and motivations, and early stage funding activities. Summarizing, these six subjects are heterogeneous within the context of digital services and potentially provide a level of generalizability beyond their context (Leonard-Barton, 1990).

Data was collected from a variety of archival sources, including critical histories authored by independent journalists, websites, press releases and news articles. For data sources that come from electronic sources (such as press releases, newsletters and corporate milestones), these were directly imported into the database. For data sources that required manual extraction of data, such as books, any action or incident that occurs was manually noted. The time frame ranged from the initial idea of the digital service, to the time when the success of the digital service and ecosystem are commonly acknowledged. Thus data collection often began before the digital service or company was launched, and finished a number of years later; for completeness an additional year was added after the commonly acknowledged success date (see Table 1). Following Garud and Van De Ven (1989), a discrete view of time was taken with the day as the temporal measurement unit. For incidents where an exact date could not be ascertained, an approximate date was utilized and noted. From this basis a case narrative and timeline was compiled for each subject in order to gain an overview of each.

It is important to distinguish between an incident as a raw datum, and an event as a theoretical construct (Abbott, 1984), at To develop a model of ecosystem emergence requires statements about the temporal sequence of events that explain an observed stream of incidents (Poole, Van De Ven, Dooley, & Holmes, 2000). Whereas an incident is an empirical observation, an event is not directly observed; it is a construct in a model that explains a pattern of incidents. For each event one can choose any number of incidents as indicators of the event, requiring a method called colligation (Abbott, 1984; McCullagh, 1978; Walsh, 1958; Whewell, 1847). The first element of colligation is to understand the levels of analysis so as to tell a coherent story (Abbott, 1990b). Here relevant levels of analysis include the ecosystem, the digital service and the organization that provides that service, and consistent with Garud and Van De Ven (1989) and theory, the wider environmental context. The next element of colligation consists of assembling the narrative by deciding its essential events at each of those levels and ensuring the same event granularity at each level (Abbott, 1984; Abbott, 1990b). Here decision rules based around the nature of the incident were utilized, such as whether the incident was publicised in some way, named as critical or as a milestone, consisted in a change in the functionality or capability, or mentioned more than once from the data sources. In order to ensure similar granularity, where a group of incidents occurred over a number of days then they were gathered together into a single event.

To organize these events into a format conducive for process analysis, they were then coded using the four conceptual categories suggested by the theoretical development – resource, technological, institutional, context. The codes were applied multi-functionally, meaning that multiple codes were applied to a single event, aligning with the concept of processes as multiple, intertwining narratives (Abbott, 1990a). For instance, a strategic partnership between a hub firm and a complementary asset provider which also involved a functional improvement to the digital service would be coded two times: once for the resource acquisition and once for the technological improvement.

Following the application of codes to the events, the data now consisted of six sequences of activity codes, for example, a subset of the code sequence could appear as follows, R-T-C-T-R-I-C, with 'R' signifying a resource activity, 'T' a technology activity, 'I' an institutional activity and 'C' a context activity. A number of phasic analysis techniques were applied to these coded sequences: optimal matching, direct inspection and frequency analysis. Phasic analysis attempts to capture the overall coherency of development and change at a higher level than fine-grained micro-level structure (Poole et al., 2000). The fundamental assumption of phasic analysis is that the overall process can be described in units larger than the underlying events. Analysis was conducted using the R open source statistical software (R Core Team, 2012) with the TraMineR package for optimal matching (Studer, Ritschard, Gabadinho, & Müller, 2011).

Optimal matching is a technique that compares whether two sequences have similarities in the pattern of the codes, and requires that each sequence is represented by well-defined elements drawn from an alphabet of relatively small set of (repeating) event types (Poole et al., 2000). Optimal matching produces an index of the relative "distance" between any two sequences, and can be utilized on sequences of differing lengths. This index, known as the Levenshtein index, is the smallest possible cost of operations of insertion, substitution and deletion of sequence units required to align the two sequences. Put differently, this index represents the effort required to transform one sequence into another. As such the higher number returned in the index, the more different the sequences. A cost matrix determines the effort required for each insertion, substitution or deletion of a sequence element. The analysis utilized the TRATE method, such that the insertion, substitution or deletion cost is determined by the rate of transition from one code to another. Here the transition rates are the probabilities of transition from one code to another observed in the sequence.

The distance in itself is not necessarily that interesting; the subject sequences are of differing lengths with different frequencies of codes and hence not meaningfully comparable. Thus in order to meaningfully compare the distance between any two sequences, it is necessary to compare the actual distances with a standard measure. To produce this standard measure, 10,000 random sequences were generated for each subject maintaining the same code frequency within each random sequence, and the distance between each random sequence calculated for the each subject comparison. The mean distance and standard deviation were then calculated for each subject comparison; here the mean represents the distance of any two random sequences. Thus a negative distance from the mean signifies that the sequence is more similar than two random sequences with the same code distribution, and a positive distance from the mean signifies that the sequence is less similar than two random sequences with the same code distribution.

A second technique utilized was direct inspection to determine if phases are suggested in the data. Utilizing the case narratives and timelines, this qualitative technique was complemented by quantitative analysis of the code frequency. One frequency measure utilized is the variance from the overall occurrence of each code. Here the sign of the variance indicates whether the code occurred more or less than overall. A second frequency measure is the count of the occurrence of codes over a moving window (of a size of a set number of events, say 25) that progresses along the sequence. As a code occurs within the window the code count increases by one, and as the moving window moves past the code, the count decreases by one. This technique provides a visual aid that provides the relative frequency of codes at any point within the sequence and also implies rates of change.

RESULTS

Full sequence comparison

The first analysis considered the similarity of the complete sequences for all six subjects, utilizing optimal matching to determine the distance between each subject. (See Figure 1 for code frequency across the six subjects.[2]) The results are indicate that the majority, with the exception of Amazon/eBay and Amazon/Facebook, are significantly (mostly $p<0.001$) dissimilar to each other. The results are detailed in Figure 2.

[Insert Figure 1 and Figure 2 around here]

This is an interesting finding. Put another way, the significant positive variance from the mean indicates that each subject has a sequence that is different to random, and that both these sequences are significantly different to each other. In the case of those distances which were not significant, in all cases the sign of the variance are still positive. Together this suggests that each subject has travelled its own route from idea to dominance and that there is not a common sequence across the subjects; the ecosystem for each subject has emerged equifinally.

To check the robustness of these results the optimal matching process was run again using a constant cost matrix rather than a transition rate cost matrix; a constant cost matrix costs each code insertion, substitution and deletion at a constant rate. Using this more conservative measure the level of the significance was reduced on the variance, but all variances for all subject comparisons remained positive.

Phase identification

Given that each subject has a unique sequence in comparison to the others, direct inspection analysis was utilized to determine if phases existed within these sequences. Although the overall sequences are significantly different, phases within the sequences are possible as each subject may have experienced the same sub-sequences, just in different ways. Through an analysis of the timelines and case narratives, as well as through frequency analysis, three phases are suggested from the data (see the Appendix for details of the qualitative anlysis).

[Insert Figure 3 around here]

[2] Each subject has a higher code count than event count as some events were coded multiple times.

Phase I, or *Initiation*, consists of the initial idea and digital service development, resource gathering and early operation. Early operation consisted of initially restricted access, sense- and rule-making, low levels of promotion, little press coverage, and insignificant competitor activity. In Phase II, or *Momentum*, the ecosystem begins to grow rapidly, driven by incoming investment, increasing numbers of participants (drive by positive network effects), aggressive marketing, much press and societal interest, as well as competitor activity. During this phase ecosystem growth is the main goal, with much discourse between participants and the hub firm, receipt of awards from commentators, as well as high levels of press and societal interest as the ecosystem and digital service are established in society. In Phase III, or *Optimization*, the focus of activity moves from expansion to control and value appropriation. With the ecosystem established as the undisputed leader focus now shifts to closer control of the activities of ecosystem participants and value appropriation.

The existence of these phases was validated through optimal matching. Similar to the optimal matching analysis above, a positive variance from the mean signifies that the difference between the two sequences is greater than random; as the purpose of this analysis is to confirm that the phases are different to each other, a positive value here signifies that the phases are more different than random. The results are detailed in Figure 4.

[Insert Figure 4 around here]

For Facebook, Google, Salesforce and Wikipedia, optimal matching analysis indicates that each phase is significantly different to the others, with a variance from the random mean for each pair of phases positive and significant. For both Amazon and eBay, the variances from random of the Phase I/II and Phase II/III distances are positive and significant ($p<0.01$ for Amazon and $p<0.001$ for eBay). However the variance from the random mean for Phase I/III is positive but not significant, suggesting that the two phases are no more different than two random sequences. However as Phase I is significantly different to Phase II, and Phase II is significantly different to Phase III these results still validate the phase identification. For robustness a constant cost matrix was applied, and there was no substantive change to these results.

Cross case comparison

The above suggests that there are three phases of ecosystem emergence, however it is not clear whether the sequence of activities for one subject are similar to the sequence of activities for another in a particular phase. Here optimal matching can be utilized to determine how similar or different a phase is across subjects. The results are detailed in Figure 5. For robustness a constant cost matrix was also applied, and there was no substantive change to these results.

[Insert Figure 5 around here]

The Phase I cross-subject comparison suggests that there is significant *similarity* between the phases across the subjects. In particular, Amazon/Facebook, Amazon/Google, Amazon/Salesforce, eBay/Facebook, Salesforce/Facebook and Google/Facebook are have a significant negative variance from the mean, indicating that the sequences are more similar than two random sequences. In addition Amazon/eBay also has a negative sign but is not significant. Interestingly, the variance of eBay/Google and eBay/Salesforce are positive but not significant; this could be due to the high levels of institutional activity early in the operation of eBay. A further interesting finding is that the Google/Facebook variance is significantly positive. This may be due to the major funding issues that Facebook experienced as one of the founders withdraw. In contrast Wikipedia exhibits a positive variance from the mean for all other subject comparisons, with Wikipedia/eBay, Wikipedia/Facebook and Wikipedia/Salesforce significant. These results seem to indicate that for-profit ecosystems which do not have substantial community involvement in the establishment of the ecosystem have similar initiation processes. However those ecosystems that are not-for-profit or which have substantial community involvement are significantly different.

In contrast, the Phase II cross-subject comparison shows that there is *dissimilarity* between the sequences for the majority of the subjects. Apart from Google/eBay and Salesforce/Facebook, all variances from the random mean are positive and with the majority significant (with the exception of Facebook/Amazon and Salesforce/Google). Both Google/eBay and Salesforce/Facebook have negative variances, however these are not significant. In essence, these results suggest that the ecosystem momentum processes are unique to the ecosystem; each ecosystem grows in its own way.

Phase III appears to continue the *significant dissimilarities* between the sequences for all subjects. In particular, the variance from the random for all subject comparisons is positive, with the majority significant (the exceptions are Amazon/eBay, Amazon/Salesforce, eBay/Facebook, eBay/Wikipedia, Google/Facebook, and Wikipedia/Facebook). This is a surprising result. Given that in this phase the ecosystems are now moving towards optimization, value appropriation and control, it would be reasonable to consider that wider institutional concerns, particularly regulatory pressures, would exert an homogenizing influence on activities. However this does not appear to be the case. Instead it appears that earlier history and the differing business models of each ecosystem results in unique optimization processes. Thus it is suggested that the optimization activities for each subject are a product of the momentum phase, underlining the importance of path dependency within ecosystem emergence.

DISCUSSION AND CONCLUSION

The above analysis indicates that the processes of ecosystems creation are unique to the ecosystem – each ecosystem emerges in its own manner. However the analysis above also suggests that despite the unique sequence of emergence, there are three common phases – Initiation, Momentum and Optimization. A further finding is that there is similarity in the structure of the Initiation activities between differing ecosystems, however as the ecosystem emerges through the Momentum and Optimization phases, the early differences within the ecosystem result in significant process differences.

The finding that the emergence process of an ecosystem is unique has a range of support within the institutional formation literature. The dominant design, social movement and institutional theory literatures all highlight the emergent and path dependent nature of organizational structures, as well as identifying underlying commonalities (Garud & Karnoe, 2001; Hariharan & Prahalad, 1991; Rao, 1998; Suarez, 2004). Importantly the institutional literature also emphasizes that the logics and power relationships within any particular institutional field are unique (Fligstein, 2001; Scott, 2008). Similarly, Garud and Karnoe (2003) have suggested that as an ecosystem begins to gain momentum the emerging path both enables and constrains the activities of involved actors.

The finding of the Initiation, Momentum and Optimization phases provides substantive empirical support for the existing ecosystem emergence model of Moore (1993). Moore proposes four phases of evolution – birth, expansion, leadership and self-renewal – where the first three approximately match those of Initiation, Momentum and Optimization. The Initiation phase includes both the birth phase, where the hub firm works with customers and suppliers to define the value proposition as well as protecting the idea from others, and part of the expansion phase, in particular introduction of the new offering to market. The Momentum phase includes remaining elements of the expansion phase, particularly the attainment of competitive success and domination of the key market segment. The Optimization phase finally includes the Moore's leadership phase where the hub firm provides a compelling vision for the future as well as maintaining strong bargaining power in relation to other participants in the ecosystem.

These findings also support existing dominant design process theories. For instance, the five phase model of dominant design emergence of Suarez (2004) has parallels with the identified ecosystem emergence model. Suarez suggests that each of the five phases in his model – R&D build-up, technical feasibility, market creation, decisive battle and post dominance – are path dependent and which exhibit differing dynamics. In relation to the ecosystem emergence model, the Initiation phase echoes the first two phases, R&D build up and technical feasibility, as here the digital service is first development and initially released, de facto testing the technical feasibility. Similarly the ecosystem Momentum phase echoes the market creation and decisive battle phases of Suarez, with the rapid ecosystem growth and competitive battles an important element. Finally the Optimization phase also echoes matches the post dominance phase of Suarez, considering who the installed base and network effect maintains market dominance. The Momentum phase also empirically reflects the observations of Garud and Karnoe (2003) who suggest that the accumulation of inputs from multiple actors generates a momentum that can harness the inputs of distributed actors. In particular they emphasise how a technology evolves through the involvement of participants who regulate, evaluate, design & produce and use the technological artefact.

These findings also support the suggestions of an evolutionary dynamic in both dominant design and institutional entrepreneurship theory, such as Van De Ven and Garud (1994) and Barley and Tolbert (1997). In particular, both suggest a variance, selection, retention mechanism which drives institutional emergence. This particular dynamic was observed in the subjects where there was strong community development and identity, such as eBay and Wikipedia. More broadly, the results also reflect the sequential process models of institutional entrepreneurship. For instance, Greenwood et al. (2002) and Hinings et al. (2004) suggest that following a precipitating jolt (here the arrival of the internet), there is an emergence of new actors who begin new practices and introduce technically viable innovations (here the digital service), echoing the Initiation phase of ecosystem emergence. There follows processes of theorization, legitimation and dissemination (here coded as institutional events) which lead to the commitment and satisfaction of interests of the participants, as well as a power structure. This echoes the Momentum phase of ecosystem emergence. Following the successful emergence of a powerful structure, there is a re-institutionalization of the field, characterized by powerful field level actors emerge (here enabling the Optimization processes). This reflects the fact that Optimization processes would not be able to occur unless the hub firm was in a powerful position. The findings also support the institutional models what argue that institutionalisation and collaboration are interdependent. For instance, Phillips et al. (2000) suggest that institutional fields provide the rules and resources upon which collaboration is constructed, and collaboration provides a context for the on-going processes of structuration that sustain the institutional fields of the participants.

To conclude, through a synthesis of the dominant design, social movement and institutional entrepreneurship literatures, four ecosystem emergence activities are proposed – resource, technological, institutional, context – that drive the creation processes of ecosystems. Utilizing these four activities, the emergence processes of six digital services were empirically analyzed using phasic analysis to determine the similarities and differences between each creation sequence. Three phases of ecosystem emergence were suggested – Initiation, Momentum, and Optimization – where cross subject similarities decreases from one phase to the next as the ecosystem emerges. In particular the cross-subject analysis emphasizes the path dependent nature of ecosystem emergence.

We hope that these findings will inspire researchers to further investigate how ecosystems emerge.

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TABLE 1 – Subject Overview

	Amazon	Ebay	Facebook	Google	Salesforce	Wikipedia
Year founded	1994	1995	2004	1998	1999	2001
Years of study	1994 - 2004	1994 – 2001	2003 - 2009	1996 – 2005	1999 – 2006	2000 – 2008
Founder	Jeff Bezos	Pierre Omidyar	Mark Zuckerberg	Sergei Brin & Larry Page	Marc Benioff	Jimmy Wales
Founder background	Hedge Fund executive	Software engineer	Undergraduate student	Doctoral students	Software executive	Bank trader
Founding ideal	Commercial success	Create the perfect market	Make the world more open	Make all the world's information freely accessible and available	Free the business from enterprise software	Free access to the world's knowledge
Competitors at founding	Books.com; clbooks.com	None	MySpace.com; Friendster.com;	Yahoo!; Altavista; Excite	None	Encyclopaedias
Initial Funding	Founder & Family	Founder	Founders	Founder	Founder & Angel investors	Founder
IPO	1997	1998	2012	2004	2003	N/A
Year became profitable	2001	1995	TBD	TBD	2002	N/A
Business Model	Retail	Brokerage	Social Advertising	Search Advertising	Subscription	Open Source
Marketing Approach	Word of mouth	Word of mouth	Word of mouth	Word of Mouth	Guerrilla	Word of Mouth
Major Crisis Event	Dotcom crash	Technology failure	Privacy	Privacy	Technology failure	Quality
Effect of dotcom crash	Major; potential for bankruptcy	Minor; slump in listings	Not Applicable	None	Mid; cash-flow issue solved through fee restructure	Not Applicable
Ecosystem participants	Customer community, wholesaler suppliers, distributors, partner websites, associate websites, marketplace vendors	Customer community, escrow services, insurance services, information services, software, packaging materials, collection and sales	User community, app developers, advertisers, Connect enabled websites, 'Like' enabled websites	Customer community, advertisers, advertising affiliates, search affiliates, app developers	Customer community, consultancies, solution developers, AppExchange developers, software partnerships, publishing	Users, editorial community, bot developers, add-on developers
Number of incidents	1453	941	964	985	990	1307
Number of events	678	467	465	576	731	659

FIGURE 1 – Code Descriptive Statistics

All Subjects

	Amazon	eBay	Facebook	Google	Salesforce	Wikipedia
Resource	27.94% (195)	25.57% (123)	18.36% (94)	22.64% (134)	15.28% (114)	7.61% (51)
Techology	26.79% (187)	20.58% (99)	38.48% (197)	34.8 % (206)	13.67% (102)	33.13% (222)
Institutional	29.37% (205)	40.96% (197)	19.14% (98)	20.78% (123)	50.67% (378)	39.25% (263)
Context	15.9 % (111)	12.89% (62)	24.02% (123)	21.79% (129)	20.38% (152)	20.0 % (134)
Total	100.0 % (698)	100.0 % (481)	100.0 % (512)	100.0 % (592)	100.0 % (746)	100.0 % (670)

Number in parenthesis represents actual count.

FIGURE 2 – Optimal Matching of Complete Subject Sequences

(Variance from 10,000 random iterations)

Complete Sequence

	Amazon	eBay	Facebook	Google	Salesforce	Wikipedia
Amazon	0.0 (0.0)					
eBay	0.017 + (0.593)	0.0 (0.0)				
Facebook	0.005 (0.617)	0.005 (0.684)	0.0 (0.0)			
Google	0.035 *** (0.642)	0.02 + (0.663)	0.011 (0.616)	0.0 (0.0)		
Salesforce	0.008 (0.674)	0.044 *** (0.632)	0.018 + (0.698)	0.02 * (0.703)	0.0 (0.0)	
Wikipedia	0.078 *** (0.741)	0.024 ** (0.634)	0.043 *** (0.662)	0.058 *** (0.701)	0.056 *** (0.665)	0.0 (0.0)

Note: + p<0.1; * p<0.05; ** p<0.01; *** p<0.001; Numbers in parentheses are actual distance.
A positive variance represents greater distance between the sequences.

FIGURE 3 – Moving Windows Code Frequency Analysis for Each Subject

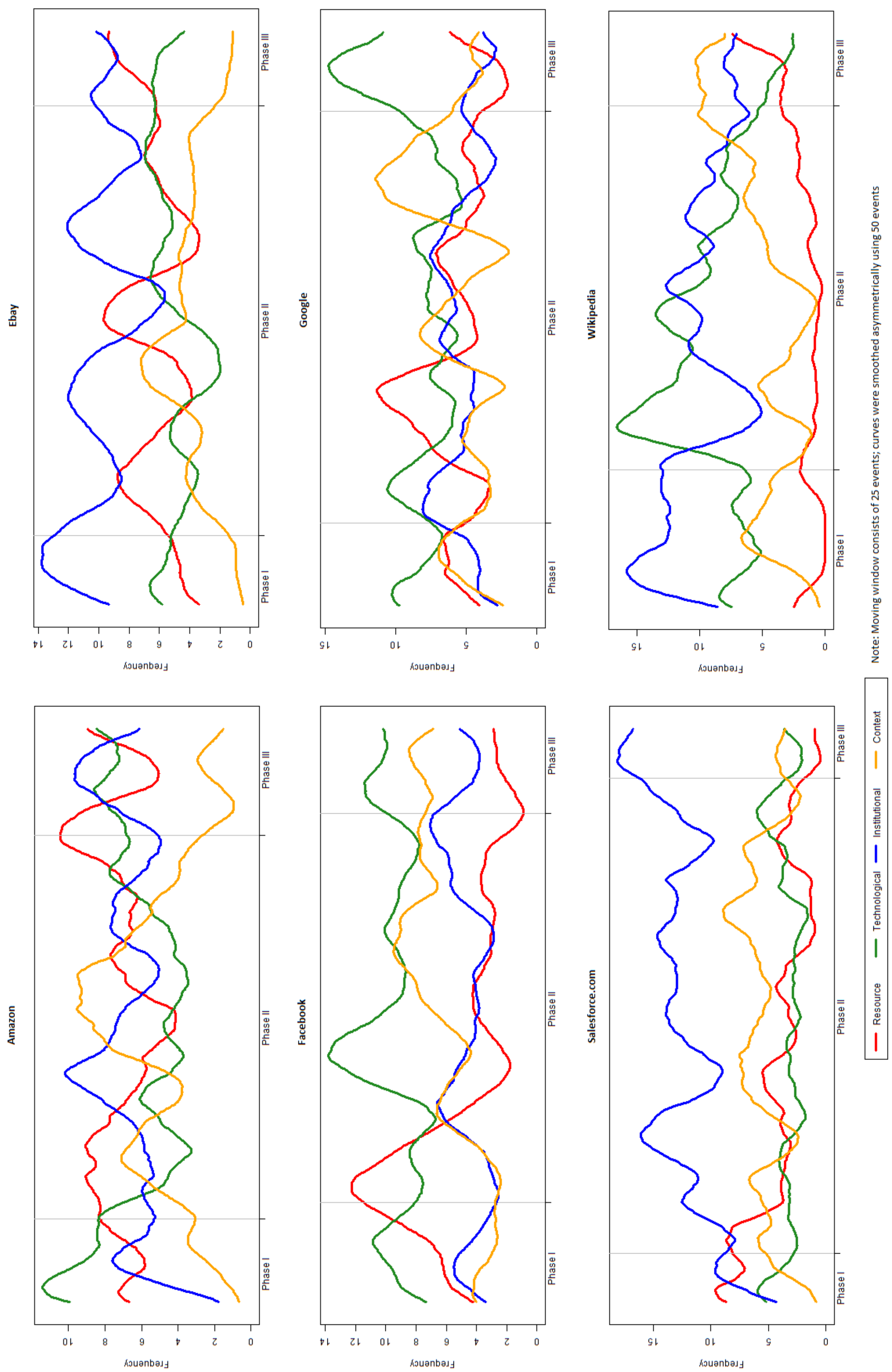

FIGURE 4 – Internal Phase Optimal Matching

(Variance from 10,000 random iterations)

Amazon

	PHASE I	PHASE II	PHASE III
PHASE I	0.0 (0.0)		
PHASE II	0.005 ** (0.782)	0.0 (0.0)	
PHASE III	0.009 (0.7)	0.033 * (0.61)	0.0 (0.0)

Google

	PHASE I	PHASE II	PHASE III
PHASE I	0.0 (0.0)		
PHASE II	0.21 *** (0.797)	0.0 (0.0)	
PHASE III	0.071 * (0.672)	0.1 *** (0.704)	0.0 (0.0)

eBay

	PHASE I	PHASE II	PHASE III
PHASE I	0.0 (0.0)		
PHASE II	0.141 *** (0.836)	0.0 (0.0)	
PHASE III	0.024 (0.602)	0.085 *** (0.703)	0.0 (0.0)

Salesforce

	PHASE I	PHASE II	PHASE III
PHASE I	0.0 (0.0)		
PHASE II	0.018 *** (0.896)	0.0 (0.0)	
PHASE III	0.129 *** (0.831)	0.163 *** (0.811)	0.0 (0.0)

Facebook

	PHASE I	PHASE II	PHASE III
PHASE I	0.0 (0.0)		
PHASE II	0.115 *** (0.747)	0.0 (0.0)	
PHASE III	0.039 * (0.635)	0.071 *** (0.672)	0.0 (0.0)

Wikipedia

	PHASE I	PHASE II	PHASE III
PHASE I	0.0 (0.0)		
PHASE II	0.015 + (0.65)	0.0 (0.0)	
PHASE III	0.186 *** (0.733)	0.075 *** (0.765)	0.0 (0.0)

Note: + p<0.1; * p<0.05; ** p<0.01; *** p<0.001; Numbers in parentheses are actual distance.
A positive variance represents greater distance between the sequences.

FIGURE 5 – Cross-Case Optimal Matching

(Variance from 10,000 random iterations)

Phase I - Initiation

	Amazon	eBay	Facebook	Google	Salesforce	Wikipedia
Amazon	0.0 (0.0)					
eBay	-0.032 (0.626)	0.0 (0.0)				
Facebook	-0.023 + (0.65)	-0.031 + (0.648)	0.0 (0.0)			
Google	-0.083 *** (0.557)	0.025 (0.676)	0.041 + (0.645)	0.0 (0.0)		
Salesforce	-0.118 * (0.531)	0.015 (0.608)	-0.101 *** (0.637)	-0.041 * (0.669)	0.0 (0.0)	
Wikipedia	0.012 (0.686)	0.076 * (0.718)	0.101 *** (0.728)	0.023 (0.692)	0.117 *** (0.794)	0.0 (0.0)

Phase II - Momentum

	Amazon	eBay	Facebook	Google	Salesforce	Wikipedia
Amazon	0.0 (0.0)					
eBay	0.049 *** (0.633)	0.0 (0.0)				
Facebook	0.013 (0.634)	0.076 *** (0.739)	0.0 (0.0)			
Google	0.09 *** (0.691)	-0.032 (0.657)	0.058 *** (0.654)	0.0 (0.0)		
Salesforce	0.008 (0.648)	0.032 ** (0.641)	-0.002 (0.701)	0.002 (0.68)	0.0 (0.0)	
Wikipedia	0.097 *** (0.765)	0.086 *** (0.698)	0.037 ** (0.673)	0.103 *** (0.735)	0.063 *** (0.665)	0.0 (0.0)

Phase III - Control

	Amazon	eBay	Facebook	Google	Salesforce	Wikipedia
Amazon	0.0 (0.0)					
eBay	0.014 (0.627)	0.0 (0.0)				
Facebook	0.058 *** (0.698)	0.039 (0.756)	0.0 (0.0)			
Google	0.049 ** (0.662)	0.071 * (0.748)	0.035 (0.644)	0.0 (0.0)		
Salesforce	0.021 (0.648)	0.116 *** (0.72)	0.145 *** (0.824)	0.21 *** (0.904)	0.0 (0.0)	
Wikipedia	0.13 *** (0.759)	0.013 (0.698)	0.054 (0.726)	0.14 *** (0.806)	0.16 *** (0.77)	0.0 (0.0)

Note: + $p<0.1$; * $p<0.05$; ** $p<0.01$; *** $p<0.001$; Numbers in parentheses are actual distance.
A positive variance represents greater distance between the sequences.