The role of emergence in dynamic capabilities

The role of emergence in dynamic capabilities: a restatement of the framework and some possibilities for future research[1]

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ABSTRACT

Dynamic capabilities has been mischaracterized by derivative interpretations of the original concept, with variation in terms, core assumptions, and methodologies. However, in its original formulation dynamic capabilities was a framework rooted in organizational economics. We take the original formulation as a starting point to explore the relevance of the concept of emergence to the framework today. This perspective leads to a reinterpretation of the role of complementarities, co-specialization, rules, co-evolution and the ecosystem in the dynamic capabilities framework. The paper concludes with directions for research that this new frame of reference helps identify.

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1. Introduction

In this paper we examine how the concept of *emergence* can help clarify the source and nature of dynamic capabilities and their role in the firm. We also use this perspective to reappraise the relationship of dynamic capabilities to complementarities, rules and the ecosystem. This sorting out process also draws on the concept of lexical ambiguity (where words can have more than one meaning) to deal with some issues of confusion and controversy in the literature. Emergence itself is a concept which can be subject to lexical ambiguity. There are various definitions of emergence but an important distinction can be made between diachronic emergence and synchronic emergence. The distinction mirrors that in linguistics where diachronic (or historical) linguistics analyses the development of a language *over time* while synchronic linguistics focuses on the study of a language *at a point in time*.

The role of time in different interpretations of emergence is usefully illustrated by Harper and Endres (2012) in the context of capital formation and structure. Diachronic emergence is to be found in the historical processes of capital formation and evolution as in the case of new versions of the iPhone developing or emerging out of previous models (Harper and Endres, 2012, p.362). By contrast, synchronic emergence reflects relationships between lower and higher levels in a system at a point in time and is essentially anti-reductionist in that the associated higher level properties or patterns cannot be reduced to explanation based on lower level properties or characteristics. The iPhone-user system can be described as synchronically emergent in that its properties and characteristics cannot be simply reduced to or identified with descriptions of individual components or subsystems (Harper and Endres, 2012, p.362).

Harper and Endres (2012) discussion of diachronic and synchronic emergence in economic applications is of particular relevance here because the roots of dynamic capabilities also lie in economic analyses (Teece, Pisano and Shuen, 1997). However, traditional or neoclassical economics tends to be intrinsically reductionist in nature (Coddington, 1976; Kay, 1979; Nicolaides,1988) with macrosystems definable in terms of individual demand and supply all the way up to aggregate demand and supply. The reductionist notion that the economic system is simply composed of aggregates has helped economics develop tools of tremendous range and scope However a price has been paid for the economy-wide scaleability of analysis based on microlevel elements, and that price is the neglect of complex non-aggregative emergent organizational phenomena such as "bureaucracy", "culture" and "network". So while we acknowledge the debt that the study of dynamic capabilities owes to economics, we are also conscious of the limitations of traditional economic analysis in terms of being able to recognise and handle synchronically emergent phenomena.

We shall look these issues more closely in Section 4 but first we note that the concept of "emergence" is most commonly associated today in the scholarly literature with complexity theory. In complexity theory, "self-organization" (spontaneous order and organization arising from local interactions of component parts) is the phenomenon that tends to be associated with emergence. However, as discussed below, emergence is a concept that both predates and extends beyond modern complexity theory.

While we recognise that self-organization has been applied in many areas of the social sciences, including management, it is first of all important to emphasise and explain why we will not be looking at self-organization as such. There are two reasons for this. First, we

believe that much of what has been described as "self-organization" in organizational analysis might better be described as quasi-autonomous team organization. For example, in ecology the self-organization associated with flocking, herding and shoaling behavior has been amenable to computer simulation in terms of shared simple rules at the level of individual agents. The same cannot be said for quasi-autonomous team organization where leadership, higher cognitive skills, negotiation and agreement can still play central roles. The latter implies a very different type of phenomenon from that associated with self-organization in complexity theory. Unfortunately, self-organization as used in organization analysis itself can reflect lexical ambiguity with different meanings of that term leading to confusion.

Second, the dynamic capabilities framework is designed to advance understanding in the field of competitive strategy. Even where self-organization has been found to be applicable (as in ecology with the self-organization of flocks, herds and shoals) it can be inferior to strategizing. For example, the self-organization represented by fish shoals has been analysed as an evolutionary defence against predation because solitary fish are more likely to be attacked on average than fish in shoals (e.g. Godin, 1986). However, while shoaling has evolved in part as a defence against natural predators it can be also a weakness exploited by predators capable of learning, adapting, communicating and coordinating, such as pods of orcas (killer whales). Orcas have developed a variety of effective hunting techniques that can vary with locality and pod and which have been developed to use the shoaling behaviour of their prey against them (e.g. van Opzeeland, Corkeron, Leyssen, Simila and Van Parijs,2005; Samarra and Miller, 2015). Self-organization is dependent on automaticity and when automaticity competes with strategy, strategizing capabilities may be a source of competitive advantage. In this paper we shall be focusing on the role of higher cognitive abilities and strategizing and not lower level functions such as self-organization.

The dynamic capabilities framework is examined in section 2 where we trace its development and efforts to capture and modify it by various scholarly communities. In section 3 we trace how the dynamic capabilities concept has undergone a process of speciation where variants can be identified by core assumptions and methodology. The concept of emergence is introduced in section 4 and its potential relevance to dynamic capabilities examined in section 5. Emergence is then used to reinterpret the role of complementarities (section 6), rules (section 7), and the ecosystem (section 8) in the context of dynamic capabilities. We finish with a short concluding section where we also consider some possibilities for future research.

2. The development of the dynamic capabilities framework

Dynamic capabilities as first developed was wedded to organizational economics (Teece and Pisano 1994; Teece, Pisano and Shuen, 1997; Augier and Teece, 2008). This orientation has imbued it with genetic markers that reflect its ancestry. The intellectual lineage can be traced to economists such as Schumpeter (1942), Penrose (1959), Richardson (1972), Nelson and Winter (1982) and Teece (1986a, 1986b). Like evolutionary and institutional economics (but in contradistinction to neoclassical economics) it puts innovation and change center stage.

Dynamic capabilities were defined in Teece et al (1997) as "the firm's ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments" (p. 516). The paper juxtaposed dynamic capabilities against three previous economics-oriented frameworks: first, the Five Forces framework (Porter, 1980) which drew on the structure-conduct-performance framework, a managerial wing of industrial organization economics; second the strategic conflict approach (*e.g.*, Shapiro, 1989), which used insights from game theory; and third, scarcity-based approaches which included the resource-based view (RBV) that analyzed the relation of firm-specific

capabilities and assets to firm performance (Penrose, 1959; Rumelt, 1984; Teece, 1984; Wernerfelt, 1984; Augier and Teece, 2008).

Each of these economics frameworks shared common ground with an appreciation and concern with rationality (including bounded rationality), competition, market entry and exit, efficiency and approprability; and each approach also embraced (usually implicitly) the notion of firm level heterogeneity. However, the dynamic capabilities framework went deeper inside the black box of the firm than did its predecessor frameworks and also brought the entrepreneur, the manager, dynamics, and knowhow onto center stage. Teece et al. (1997) can be read as behavioral and organizational economics paying attention to both the generation and appropriation of economic rents to sustain long term growth and development.

Teece (2007) later identified the microfoundations of dynamic capabilities as consisting of clusters of capabilities that: "(1) sense and shape opportunities and threats, (2) seize opportunities, and (3) maintain competitiveness through enhancing, combining, protecting, and, when necessary, reconfiguring the business enterprise's intangible and tangible assets." (p. 1319). The framework analyzes the conditions under which a firm can generate long term Schumpeterian rents in a business environment characterized by rapid technological change. Competitive advantage in this view is founded on the firm's particular competences; on identifying the likely path of technological and market evolution; and on integrating its own specific bundle of difficult-to-trade complementary and knowledge assets, both internal and external to the firm, so as to achieve durable competitive advantage.

In this perspective dynamic capabilities involve higher-level activities that can be contrasted with what Helfat and Winter (2011) call "operational capabilities." Ordinary capabilities govern the firm's abilities to perform certain necessary administrative-, operational- and governance-related functions (Teece, 2014), although not necessarily internally within the firm. Winter (2003) defined zero-level (i.e. ordinary) capabilities as doing more or less the same thing on an ongoing basis in order to make a living in the present. The development and prompt application of ordinary capabilities can support best practices. Dynamic capabilities require going beyond best practice and technical fitness which are the preserve of ordinary capabilities, they are instead aimed at evolutionary fitness. In this framework, doing the right things is paramount. Doing things right is a secondary issue.

The dynamic capabilities framework has been used by scholars in a range of disciplines, including strategic management (e.g., Helfat et al., 2009), entrepreneurship (e.g., Zahra et al., 2006), marketing (e.g., Day, 2011) and information technology management (e.g., Sambamurthy et al., 2003). It has been used by both practitioners and scholars (Easterby-Smith et al., 2009).

However, the growth of the dynamic capabilities literature been accompanied by different understandings of dynamic capabilities. As a result, the broader literature is infused with inconsistencies, overlapping definitions, and even with contradictions (Salvato, 2003). Such contradictions result, in part, from differences in the disciplines and methodological perspectives of researchers (Peteraf et al., 2013), as well as different assumptions and characterizations relating to specific environments being studied. One key source of confusion is lack of agreement about whether a dynamic capability refers to substantive capabilities in volatile environments or to the organization's ability to alter existing substantive capabilities, regardless of the volatility of the environment (Zahra et al., 2006, p. 5). We deal with that here by building on the original conception of dynamic capabilities (Teece and Pisano, 1994; Teece et al. 1997; Teece, 2007) as an organizational economics-rooted perspective. We look at this in more detail in the next section.

3: The speciation of dynamic capabilities

The evolution of dynamic capabilities has brought with it another problem common in the study of organizations, that is lexical ambiguity where the same word or phrase can take on very different meanings depending on the context or use (Kay, 2008). Machlup (1967) in his presidential address to the American Economic Association was convinced there were at least twenty-one concepts of "the firm" in business and economics, though he restricted himself to enumerating just ten. More recently, the study of dynamic capabilities has suffered from similar problems. Zahra et al (2006) list nine different definitions of "dynamic capabilities", some of which are mutually consistent, while others are less so. Barreto (2010) also cites nine different definitions, though most of the sources and definitions differ from the list of Zahra et al (2006). Ambrosini and Bowman (2009) look at seven different definitions and attempt to find coherent threads running through them. However, Cepeda and Vera (2007) conclude that there is a lack of agreement among the different definitions as to the nature of dynamic capabilities while Verona and Ravasi (2003) and Di Stefano, Peteraf and Verona (2010) also note the field is subject to a variety of conceptualisations and definitions..

These studies help highlight the confusion in the literature that exists at theoretical level. However, a less recognised but potentially more serious resultant problem relates to the commensurability of results at the empirical level. Differing conceptualizations as to what constitutes dynamic capabilities means the contribution of empirical studies do not automatically generalise beyond the specific interpretation of dynamic capabilities on which they are predicated. To claim otherwise would be rather like assuming equivalence in the principles underlying the cultivation of apples and oranges when horticulture has to recognise genus- or even species-specific principles. The same applies in principle to interpretation of the research on dynamic capabilities, but all too often surveys of empirical research in this area fail to contextualise the specific interpretation of dynamic capabilities on which each individual piece of empirical research has been based.

At the same time, there are some signs that research has been adapting to this problem despite the proliferation of interpretations of dynamic capabilities. Peteraf et al (2013) note that two approaches to dynamic capabilities have come to dominate the literature. These are what they label as the TPS approach (Teece, et al, 1997) and the EM approach (Eisenhardt and Martin, 2000). More recently, TPS was developed and explicated more fully in Teece (2007). Peteraf et al note that TPS and EM are mutually exclusive approaches with their own internally consistent logic, based on very different theoretical underpinnings and assumptions and employing different kinds of reasoning. Unsurprisingly Peteraf et al also note that TPS and EM finish up coming to very different conclusions (p.1389).

Peteraf et al also found a sharply divided field in the literature from a cocitation analysis in which they found two dense clusters of scholarship existed, one TPS cluster linked to Teece and the other and EM cluster linked to Eisenhardt. The clusters also differed in terms of education and training. Half the authors linked to Teece had advanced degrees in economics (as might be expected from the approach's roots in economics) compared to only 9 percent of those linked to Eisenhardt. Also authors in the Teece cluster tended to have stronger interests in technology, firm performance, and strategy, while those in the Eisenhardt cluster were more focused on internal organizational issues, processes, and information systems. Peteraf et al (2013) expressed concern about this lack of communication and integration involving these alternative perspectives on dynamic capabilities. They then take a contingency approach to explore how they may be reconciled and the field unified.

Peteraf and her collaborators provide an important and relevant approach to the problems they identify in their analysis. However, there is a second way to interpret Peteraf et al's (2013 findings, and that is to see them as less of a problem of failure of inter-disciplinary communication, and more in terms of mapping out positive developments in the

field. In evolutionary terms Peteraf et al (2013) could be seen as tracing a process of speciation with TPS and EM evolving as distinctive lenses through which to analyse and interpret organizations. From that point of view, clustering research around either TPS or EM focal points is not only natural, it is necessary in order to avoid misinterpretation and misapplication of empirical research findings. Major problems should then only arise if the empirical findings of work associated with the respective TPS and EM clusters are misclassified as referring to the wrong species of dynamic capabilities.

Distinguishing between TPS and EM approaches also helps highlight another fundamental difference between these two conceptualizations of dynamic capabilities. If there could be said to be a single point which triggered the process of speciation in this body of research, a good candidate would be the statement by Eisenhardt and Martin (2000) to the effect that "Dynamic capabilities are often described in vague terms such as 'routines to learn routines' that have been criticized as being tautological, endlessly recursive, and non-operational …. Yet, dynamic capabilities actually consist of identifiable and specific routines that often have been the subject of extensive empirical research in their own right" (p. 1107). In Eisenhardt and Martins' view, dynamic capabilities are characterised as commonalities in the form of best practices that are similar across firms.

An immediate problem with the EM approach is that their basic notion of best practice being replicated and diffused across firms tends to be contradicted by the empirical evidence in the economics literature which consistently finds extremely large variation in plant-level productivity between firms (Bartelsman and Doms, 2000, p.571). If best practice had been widely adopted in such cases, then we would have expected to have seen a considerable degree of convergence in productivity levels. Further, if diffusion of best practice does not take place at plant-level and other production processes, then it is difficult to see how and why it would take place for other functions of the firm where codification and standardardization of what constitutes good practice may be more problematic. But not only can diffusion of best practice often not take place across firms, best practices may be difficult to replicate even within firms (Walton,1975; Szulanski,1996). This position is consistent with evidence of wide variation in intra-firm productivity levels (Salter,1960; Chew, Bresnahan, and Clark, 1990).

However, even if there had been convergence in best practice across firms, we do not believe that it is helpful to redefine dynamic capabilities as routines or best practice, even "with some idiosyncratic details" as Eisenhardt and Martin suggest (p.1111). Indeed, consistent with RBV, we argue that the sources of competitive advantage are to be found in the very idiosyncrasies that characterise firms. These are not reducible to mere points of detail or simple rules as Eisenhardt and Martins' analysis implies. If such a reductionist perspective could be applied to dynamic capabilities then it would actually threaten to render the concept redundant since it would add no more than could be provided by studies of lower level best practices and routines. At this point the problem becomes one of methodology, and to understand the implications of this it is important to contextualise the roots of dynamic capabilities in terms of economics. Eisenhardt and Martin's criticism of previous conceptualizations of dynamic capabilities as vague, tautological, endlessly recursive, and non-operational essentially re-runs criticism of economic methodology that has been made in many contexts down the years. For example, Koplin (1963) noted criticisms of the profit maximization assumption in economics that are similar to criticism made of the TPS approach to dynamic capabilities by Eisenhardt and Martin decades later. Koplin observed that the profit maximization assumption in economics "has long been under attack, chiefly on grounds that it lacks realism", noted complaints that it is "tautological and/or unusable", with "widespread confusion and disagreement over its nature" and concluded that; "It is tempting to assert that the most 'realistic' form is best" (p.130).

Contemporaneously with Koplin, Machlup (1958 and 1967) summarised much of the criticisms of the treatment of the firm in economics as committing the fallacy of misplaced concreteness, where a theoretical construct or symbol is misconstrued as being a directly observable entity. Transaction cost economics (Williamson, 1985) is a more recent approach to problems of the firm which has been suffered similar misplaced criticism. One frequent criticism is of problems in "measuring" transaction costs in this framework, as if transaction costs in this framework could and should be directly observed and counted. That is simply not how empirical analysis is carried out in this approach, the existence of core elements such as bounded rationality and opportunism is usually assumed and not directly observed, while variability in asset specificity is usually inferred through the use of proxies (Monteverde and Teece, 1982).

The success of both neoclassical theory and transaction cost economics is best judged in terms of how well they deal with the problems they have been set in their respective domains, not in terms of how 'realistic' or otherwise their assumptions and constructs are. The TPS approach to dynamic capabilities should be judged by no less a standard. For example Arend and Bromiley (2009) in a review of dynamic capabilities research "found a lack of consensus on how to measure dynamic capabilities, with studies adopting a wide range of proxies for dynamic capabilities. These differences in measurement raise doubts about whether the measures really reflect dynamic capabilities, or even if they address the same construct"(p.85).

Arend and Bromiley do make a legitimate point about the need to question how well a specific proxy reflects dynamic capabilities. But beyond that, it is equally important to note that a wide range of proxies is not in itself necessarily a problem for a TPS approach to dynamic capabilities. Indeed, it may be unreasonable to expect any consensus on how to measure what is an unobserved variable in these approaches. On the contrary, in economics-based empirical studies a wide range of proxies may be necessary because of the context-specific nature of such research. In the case of dynamic capabilities, any specific proxy following a TPS agenda may have to reflect sector-specific or even firm-specific characteristics.

In what follows we focus mainly on the TPS interpretation of dynamic capabilities and in the next section we consider the relevance of the concept of emergence.

4. Systems Theory and Emergence

As Boulding (1956) once put it, General Systems Theory is a name used to describe a level of theory which lies between the highly general and the specific. A key objective is to develop a framework so that each specialist can communicate with another (Teece, 2018). General System Theory is inherently interdisciplinary. Boulding saw this "new" management science as a "breakaway from overly simple mechanical models in the theory of organization and control" (p207). Its anti-reductionist perspective on whole-part relations in many respects anticipated contemporary work in complexity theory and emergence.

At the same time, the concept of "emergence" has itself a long history that precedes systems theory and complexity theory in philosophical studies and in the natural and social sciences. Cohen (2010) credits Aristotle in his "Metaphysics" with one of the earliest observations of emergence when he described things whose unity he is trying to analyse as those "which have several parts and in which the totality is not, as it were, a mere heap, but the whole is something besides the parts" (p.19). Anderson (1999) provides a simple interpretation of emergence when he observes; "Complex patterns can arise from the interaction of agents that follow relatively simple rules. These patterns are 'emergent' in the sense that new properties appear at each level in a hierarchy" (p.218). With emergence, "the

whole becomes not merely more but very different from the sum of its parts (Anderson, 1972, p. 393). Emergence means that the links between individual agent actions and the long-term systemic outcome are unpredictable (Smith & Stacey, 1997, p. 83).

However, the concept itself has also been subject to lexical ambiguity which has fostered confusion in the literature. Bedau and Humphreys (2008) note that a particular division exists between accounts which describe diachronic emergence and those describing synchronic emergence (p.5). Diachronic emergence takes place over time in the sense of a butterfly "emerging" from a chrysalis. Bedau and Humphreys also give the example of traffic jams emerging over time as an example of diachronic emergence (p.5). Mintzberg's description of emergent strategy as "actions … taken, one by one, which converged in time in some sort of consistency or pattern" (1994, p. 25) is clearly diachronic.

It is also this form of emergence that appears to be used by Eisenhardt and her collaborators with respect to dynamic capabilities, for example when Eisenhardt and Martin (2000) argue that, new resource configurations "emerge, collide, split, evolve, and die" (p.1107), when routines are "purposefully simple to allow for emergent adaptation" (p. 1116), and that more generally dynamic capabilities are "path dependent in their emergence" (1105). Brown and Eisenhardt (1997) also explicitly saw emergence as a temporal concept as in "the emergence of the Internet" (p. 2), "emerging technologies (p. 20), and "semistructures emerged in each time frame." (p. 28).

It is important to note that these are entirely legitimate interpretations of emergence, they merely reflect the particular path that Eisenhardt and her collaborators in the speciation of research into dynamic capabilities and related issues. However these interpretations are quite distinct from the notions of synchronic emergence that are common in complexity theory and other areas of science and social science. As we noted, synchronic emergence is atemporal, the properties of the whole are present simultaneously with the properties of the component parts (Bedau and Humphreys, 2008, p.5). For example, in chemistry the properties of water (H_2O) cannot be deduced solely from those of its constituent elements, hydrogen and oxygen, both gases at room temperature. The words ART and RAT are composed of the same three constituent letters, but very different meanings emerge depending on the actual combination of letters. In principle there is, or should be, a clear distinction between diachronic and synchronic emergence. But the division that Bedau and Humphreys refer to in discussions of "emergence" can become a possible problem due to lexical ambiguity with the same word referring to different processes.

As far as emergence in the context of the TPS approach is concerned, we will be referring to synchronic emergence. These clarifications are important because one area in which the TPS tradition departs from its economics roots (and indeed the EM approach) is to be found in the treatment of emergence in this approach. As noted earlier, traditional economics tends to be essentially reductionist in nature and this also tends to infuse the field of organizational economics (Barney, 1990; Donaldson, 1990; Foss, 1996). Kraaijenbrink, Spender and Groen (2010) also note that RBV is itself explicitly reductionist.

However, while the reductionist approach can be appropriate for the study of many standard problem areas in economics, it faces limitations in the strategy arena (Kay, 2010). We shall explore how the concept of emergence helps show how the TPS variant of dynamic capabilities can formulate and orientate research in this area, while also providing insights not available in neoclassical economics

5. The role of emergence in the development of dynamic capabilities

We can explore the role of synchronic emergence by first deconstructing and then reconstructing dynamic capabilities with reference to Teece's (2007) article on the microfoundations of dynamic capabilities.

FIGURE 1 NEAR HERE

Teece (2007) identifies three main foundations of dynamic capabilities: (1) sensing opportunities; (2) seizing opportunities; and (3) transforming assets and organization. Each has microfoundations, for example Figure 1 from Teece (2007) analyses the constituent building blocks of the "seizing opportunities" capability; their relationships to each other; and to the overall capability.

We note first that there is a common pattern underlying all the constituent building blocks of this capability in that each is composed of a verb or verbs denoting actions (such as "delineating", "selecting" or designing") and a noun or nouns denoting that which is acted on (such as "customer solution", "business model" or "technology and product architecture").

Next, the microfoundations of this capability build on three tiers or levels of relationships, the basic building blocks are grouped into four rectangular boxes and these four boxes in turn combine to produce the capability represented in the oval at the centre of Figure 1. Figure 2 below shows how these relationships can be reconstructed as parts of a hierarchy of basic building blocks that combine to produce dynamic capabilities for the creation and maintenance of organizational competitive advantage. We take the constituents of the "Delineating the customer solution and business model" box above as starting point, these four constituents are shown as the bottom tier of Figure 2.

FIGURE 2 NEAR HERE

The next level up in Figure 2 shows the "Delineating the customer solution and business model" box combining with the other three boxes from Figure 1 to produce the "seizing opportunities" capability in the middle of the next tier up. Finally, the "seizing opportunities" capability combines with "sensing opportunities" and "transforming assets and organization" to produce the capability for "building and maintaining competitive advantage" at the top of this hierarchy. In each case the verbs (actions) associated with the specific element or capability are shown in bold while the nouns (object of the actions) are shown in brackets.

It is important to note that while this hierarchy may in practice bear some relationship to the formal organization structure as represented by an organigram, it is not the same thing and should not be confused with it. Rather the relationships shown may more usefully be thought of as analogous to the nested relationships between folders and sub-folders in the documents section of a computer. For ease of reference we shall refer to the bottom tier as comprising "routines" (or organizational microprocesses), the next tier up as made up of "themes" and the tier one up again as composed of "capabilities". We shall come back to the top tier and what it may represent in the discussion below.

The figure that has resulted from our reconstruction of the microfoundations of dynamic capabilities illustrates emergence at three distinct levels. First note the verb "delineating" in the "delineating the customer solution and business model" cannot be derived directly from the simple aggregation of the verbs in its constituent elements "selecting" and "designing". To be sure, "selecting" and "designing" may be necessary elements in the process of "delineating" but in themselves they are not sufficient. Something qualitatively different from just selecting and designing has emerged from the combination and synthesis of these lower level activities. The same holds for the nouns in brackets here;

"customer solutions and business models" are not the simple summation of technology, product and revenue architectures, target customers, and mechanisms to capture value. The twin concepts of "solution" and "model" cannot be directly inferred or derived from these lower level elements which would remain just interesting but essentially useless descriptions or data without a process of synthesis and integration.

The same basic principle holds when we move up one level from themes to capabilities. "Seizing" is an action which may involve "selecting", "delineating" and "building" activities but these constituent themes do not directly imply the qualitatively distinctive action of seizing or grasping. In turn, the nouns in these themes (decision making processes, customer solution and business model, enterprise boundaries, loyalty and commitments) may all be important ingredients in the recipe for "opportunities"; however, just adding the ingredients together would no more lead to the specification of "opportunities" than would just cooking all ingredients together without a recipe guarantee an edible cake. As Teece (2007) notes, "Dynamic capability is a meta-competence that transcends operational competence" (p. 1344).

Finally, similar points hold when we look at the relationships involved in the top tier of this hierarchy. "Sensing", "seizing" and "transforming" capabilities are all integral to successful "building and maintaining" of competitive advantage, but excellence in any (or even all) of these capabilities does not guarantee success, especially if they are conducted independently of each other. It is not just the pursuit of these capabilities which can be central to favourable outcomes but how they are choreographed and integrated, or as Teece (2007) puts it, "The enterprise will need sensing, seizing, and transformational/reconfiguring capabilities to be simultaneously developed and applied for it to build and maintain competitive advantage" (p.1341).

So what can this top tier be taken to represent? Teece (2007) helps provide the answer, he uses the term "orchestration" at various points to illustrate the process of combination and integration between levels and indeed this metaphor is a useful descriptor for the processes of emergence at all levels here. The various instruments, players and sections of an orchestra are essential elements, but this also needs a conductor creatively coordinating the resulting assembly for a symphony to emerge, rather than a cacophony. The correlate for the conductor in the enterprise is the entrepreneur or entrepreneurial management;

Teece (2007) can in retrospect be seen as capturing this process of emergence; "Maintaining dynamic capabilities thus requires entrepreneurial management. The entrepreneurial management in question is different but related to other managerial activity. Entrepreneurship is about sensing and understanding opportunities, getting things started, and finding new and better ways of putting things together. It is about creatively coordinating the assembly of disparate and usually cospecialized elements, getting 'approvals' for nonroutine activities, and sensing business opportunities. Entrepreneurial management has little to do with analyzing and optimizing. It is more about sensing and seizing - figuring out the next big opportunity and how to address it." (p. 1346). In short, "entrepreneurial management" is the emergent concept at the top tier of the firm whose responsibility it is to combine and integrate dynamic capabilities to build and maintain a competitive advantage (Augier and Teece, 2008).

Emergence in Figure 2 takes the form of qualitative step changes moving from one level to another, whether it is moving from the level of routines to that of themes, from themes to capabilities, or from capabilities to that of competitive advantage through entrepreneurial management. However, this description of multi-level emergence is not just a useful classificatory and analytical device, it can also help frame testable propositions. For example, it would suggest that firms that are successful in building and maintaining

competitive advantage are those that have mastered the task of orchestrating and integrating sensing, seizing and transforming capabilities, such as Google or Apple. A corollary is that firms that fail to build or maintain competitive advantage are those where proper synthesis of these capabilities has failed to take place, or has become dysfunctional or fractured.

Treatment of dynamic capabilities as a qualitatively distinctive phenomenon also helps to distinguish it from ordinary capabilities (Katkalo, Pitelis and Teece, 2010, p.1179). Unless care is taken, stagnation, inertia, and eventual system failure can be a consequence of routinization crowding out effective functioning of dynamic capabilities. Routinization of capabilities can mean selectivity and narrowing the scope of decision-making (Schreyögg and Kliesch-Eberl , 2007: 927) and can become sources of inertia and failure (Newey and Zahra, 2009). Path-dependence in the development of lower level routines can influence higher levels and harm the ability to innovate and change (Teece. 2007; Vergne and Durand, 2011). One possible route to distancing the firm from the risk of ordinary capabilities being a drag on dynamic capabilities is to locate them outside the boundaries of the firm.

6. Complementarities in dynamic capabilities

The construct of emergence can also provide a fresh perspective on the role of complementarities in dynamic capabilities. This is true both at the level of microfoundations (e.g. the role of complementary assets in the innovation process) or at the higher level of the dynamic (and complementary) capabilities of sensing, seizing and reconfiguring. For example, the successful commercialization of an innovation can depend on the complementary assets of marketing, manufacturing and after-sales service being used in conjunction with each other (Teece, 1986b, p. 288). Stieglitz and Heine (2007) also found that complementary assets can play a crucial role in the internal appropriation of innovative rents and also raise the need for strategic direction by an enterprise's senior management.

Cospecialized assets are a particular category of complementary assets in which an assets value is a function of its use in conjunction with other particular assets (Teece, 2007, p. 1338; Pitelis and Teece, 2010). Combinations of complementary and cospecialized assets can be regarded as constituting core technological knowhow (Teece, 1986b), where the phenomenon of core technological knowhow is an emergent property that cannot be defined or inferred from analysis of its constituent elements. Monteverde and Teece (1982), while testing for the importance of asset specificity in predicting outsourcing decisions for GM and Ford, also found a 'systems effect' that illustrates the emergent quality of complementarities in this context. They note that "The complex process of designing, producing, testing, and modifying an automobile requires a high degree of coordination. Engine, transmission, frame, body, brakes, windshield, and other components all have to perform well with each other and have to be in the right place at the right time in the right quantities" (White, 1971, p. 78: quoted in Monteverde and Teece, 1982).

But it is important to note the role of lexical ambiguity again in this context. Our interpretation of “complementarities” in terms of emergence is quite different from its treatment in neoclassical economics where it has been traditionally interpreted in terms of Edgeworth complements; "Edgeworth complementarity is a matter of order - 'doing *more* of one thing *increases* the returns to doing *more* of another'" (Milgrom and Roberts, 1995, p. 181 italics in original; see also Lange,1940, and Brynjolfsson and Milgrom, 2012). So the complementarity of two goods Y and X is not traditionally defined in economics with respect to the effect of combining these goods on any resulting novel outcome - in other words, emergence. Instead it is defined with respect to the effects of combination of these goods *on each other*. The standard economic interpretation of complementarities as described by Milgrom and Roberts above implies sequentiality, refers to the direct effect of one

complement on the other, and recognizes only quantitative change. There is no emergence of any kind; relevant concepts and measures are unchanged from one level to another.

By way of contrast, complementarities of the type described by Monteverde and Teece (1982) and Teece (2010) imply simultaneity of effect, elements that affect system capabilities directly, the importance of qualitative changes, and the emergence of novel properties not discernible from characteristics of the complements in isolation. The conceptualization of complementarity here is close to the notion of "congruence" or fit between pairs of components in organizations in Nadler and Tushman (1980).

These points reinforce the essential role of complementarities in sensing, seizing and reconfiguring capabilities. None of these categories of capabilities are sufficient by themselves to spur superior enterprise performance. Teece (2007, p. 1347) notes that "there are obvious tensions and interrelationships between and amongst the three classes of capabilities.... Successful enterprises must build and utilize all three classes of capabilities".

Whether we are looking at the innovations emerging from the integration of complementary assets, or the emergence of high performance from the exercise and oversight of (complementary) dynamic capabilities, these cases are clearly not purely analyzable in terms of the characteristics of their constituent elements. These perspectives differ fundamentally from the received reductionist frame of reference in neoclassical theory but they are strongly sympathetic to the kinds of linkages identified in complex systems in ecology where networks of interactions can generate emergent patterns and processes through overlapping or complementary ecological relations (e.g. Brown et al., 2001).

In the next section we shall argue that emergence also helps to clarify some aspects of rules in dynamic capabilities.

7. Rules in dynamic capabilities

Previous work in the EM tradition of dynamic capabilities has alluded to the potential role of simple rules. For example, Eisenhardt and Martin (2000) emphasize the necessity of some minimal structures and a few "simple rules" to prevent organizations from sliding into chaos in high-velocity environments, at the same time viewing simple rules as dynamic capabilities in high-velocity markets. They argue: "Effective dynamic capabilities in high-velocity markets are simple, not complicated as they are in moderately dynamic markets. Simple routines keep managers focused on broadly important issues without locking them into specific behaviors or the use of past experience that may be inappropriate given the actions required in a particular situation" (Eisenhardt & Martin, 2000, p. 1111). Stacey (1992) also advocates the pursuit of simple rules as a way for organizations to deal with turbulent and unknowable environments. Eisenhardt and Sull (2001) argue that: "strategy as simple rules is about being different...when business becomes complicated, strategy should be simple" (p. 116).

It is important to bear in mind that the process of speciation in dynamic capability research means that these studies are looking at different conceptualizations of dynamic capabilities from the TSP approach. At the same time notion of emergence can still help illuminate the role of rules in dynamic capabilities and strategy research in general. Rules tend to exist at all levels in the organization and can change between levels Some simple rules (eg ethics and dress codes) may stay much the same at all levels of an organization while others may emerge and/or disappear at higher levels. For example, an R&D director in an organization may have a simple rule regarding when to terminate failing projects while the Board of Directors level in the same firm may advocate a simple rule of allocating a certain percentage of sales revenue to R&D. Further, different organizations can have very different simple rules or heuristics (e.g. Pisano, 1994). Most critically, simple rules can only be part of

the story since they tend to be easily replicated (and have been, in many cases). Something else has to emerge (whether judgment, decision-making, entrepreneurial sense or interaction effects) to explain sustainable competitive advantage in these cases.

In this line of thought, although it is true that simple rules can be an integral part of dynamic capabilities, simple rules are no guarantor of sustainable competitive advantage. While simple rules have their place even in rapidly changing environments, adhering to them rigidly can be a recipe for disaster. For example, Eisenhardt and Sull's (2001) analysis cites companies pursuing simple rules successfully including Yahoo!, AOL, Dell and Enron. But a very different narrative could as easily be written today around the problems that these same companies subsequently faced from pursuing these same simple rules in their respective business environments. More generally, the elevation of simple rules beyond their essential but limited role in dynamic capabilities ignores the path dependent process through which higher-level properties actually emerge from the combination and interaction of lower level elements. Dynamic capabilities consist of more than an aggregation of routines and are not reducible to one simple routine (Teece, 2012) and much the same can be said for rules. In short, we are at odds with Eisenhardt's view that dynamic capabilities can be distilled into "simple rules".

8. The ecosystem in dynamic capabilities

Emergence may also help facilitate higher levels of analysis in the context of dynamic capabilities such as the ecosystem. Indeed the term ecosystem itself implies emergent system-level qualities. This may be seen as at least in part as a natural extension of the roles that we have already seen complementarities and cospecialisation play in emergence. Neither complementarities in general nor cospecialisation in particular are necessarily restricted to exploitation within the firm's boundaries, and indeed complementarities in practice may transcend firm boundaries and be embedded in the ecosystem.

The term "ecosystem" itself has gained prominence in both practice and theory (*e.g.*, Moore, 1996; Iansiti & Levien, 2004; Adner, 2006) and goes beyond a focal firm's boundaries to incorporate interdependencies and complementarities between organizations, teams, individuals, and customers. It overlaps with other classes of firms engaging in collaborations with other independent firms such as "innovation networks", "industrial clusters", or "meta-organizations." (e.g. Moore, 1996; Dhanaraj and Parkhe, 2006; Gulati, Puranam, and Tushman, 2012). However, unlike industrial districts or clusters, co-location among members in an ecosystem is not necessary to achieve high performance. The use of information and telecommunication technologies can improve connectivity, and modularizing tasks may substitute for collocated production (Srikanth and Puranam, 2010).

In practice, ecosystems may emerge (in the synchronic sense) in different forms. Some business ecosystems may have an ecosystem "captain" and employ proprietary interface standards. The ecosystem captain is a lead enterprise that provides coordinating mechanisms, rules, key products, intellectual property, and financial capital to create structure and momentum for the market it seeks to create. When the captain is also a "platform leader," it takes responsibility for guiding the technological evolution of the system to maintain competitiveness against rival ecosystems (Gawer and Cusumano, 2002, p. 245). Production systems such as the iPod ecosystem are orchestrated by a key player Apple, but other elements include the music (and video) content providers and the suppliers of DRM know-how. However, some business ecosystems involve collaborative production communities without any key players, for example Wikipedia and innovation networks such as Procter & Gamble's extended ecosystem (Reeves & Bernhardt, 2011). Other ecosystems may be tenuous and fragile, for example networks creating dynamic capabilities that are not

governed by rigid routines and standards and are idiosyncratic and transitory (Blyer & Coff, 2003. p. 683)

Such emergent capabilities may give the ecosystem its distinctive competitive advantage over other ecosystems. Iansiti and Levien (2004) identified the ability of an ecosystem to create niches and opportunities for new firms and new agencies as a success factor. Rothaemel and Hess (2007) argued that antecedents to dynamic capabilities reside across different levels - individual, firm and network levels. The robustness of a system also depends on its capability to reconfigure itself to face external shocks by evolving towards new functionalities and through redesigning its processes (Callaway et al., 2000).

The possession of superior capabilities is an attribute of the ecosystem as a whole, and is not reducible to what any firm has, or even to any single aggregation of the various capabilities of all individuals and sections of the firm. Compared with vertically integrated structures, ecosystems provide flexibility and co-learning mechanisms in a self-reinforcing way. ARM's ecosystem, for example, is structured through a mix of formal contracts and informal sharing based on continuous interaction so as to flexibly promote knowledge creation and software development, not only for ARM itself, but also for its partners (Williamson & DeMeyer, 2012, p. 33). Possession of various learning mechanisms by an ecosystem is partly an indication that the ecosystem has a collective dynamic capability (Zollo & Winter, 2002) which we would describe here as emergent.

Co-evolution adds an explicitly dynamic element to complementarities and co-specialization in the context of the ecosystem. Co-evolution occurs where adaptation by one kind of organization alters both the fitness and the fitness landscape of the other organizations in its business ecosystem (Kauffman 1995. p. 242). Berkes and Folke (1992, p. 4) note that "Human-environment interactions may be viewed as a co-evolutionary interrelationship in which the two sides change one another continuously by mutual feedback".

Change within an ecosystem, has to be seen in terms of co-evolution among systems, rather than as the adaptation of individual systems to their environment (Mitleton-Kelly, 2003). In a similar vein, Teece (2007, p. 1319) notes that: "Enterprises with strong dynamic capabilities ... not only adapt to business ecosystems, but also shape them through innovation and through collaboration with other enterprises, entities, and institutions", while Zollo and Winter (2002, p. 344) argued that dynamic capabilities emerge from the coevolution of tacit experience accumulation processes with explicit knowledge articulation and codification activities. This contrasts with traditional views of strategy, in particular the resource based view of the firm in which competitive advantage is determined for a single firm "*at a point in time* from the ownership of scarce but relevant and difficult-to imitate assets, especially know-how" (Teece, 2007, p. 1319, emphasis in the original). The importance of co-evolution has, for example, been especially noted in cases of cospecialized components sold by different companies supporting a common platform, generating strong functional interdependence (Teece, 2007).

One of the key benefits of participating in ecosystems can be to gain access to proprietary knowledge, participate in common standards, and coordinate capabilities development. The literature on clusters generally finds that there are cluster-specific competencies that provide competitive advantage to their constituent members as a group (Tallman et al., 2004). More broadly, Gulati (2007) refers to network resources that accrue to a firm from its ties with key external constituents. For example, Japanese firms have invested in Silicon Valley firms as a way to gain access to Silicon Valley networks and capabilities (Teece, 1992). Using complex network theory, Ferrary and Granovetter (2009) analyzed the innovative capability of Silicon Valley, which was the result of inter-firm interactions supported by social networks. They argued that successful ecosystems possess the capabilities of the complex network to collectively anticipate, learn, and innovate in order to

react to major internal or external changes. The existence of this type of cluster-specific and tacit knowledge has been found in linkages such as those in biotechnology consisting of firms, universities, and research organizations (Arora & Gambardella, 1990).

Taken together, these observations lead us to suggest that complex interactions across levels have the potential to develop, maintain and reconfigure ecosystems towards combinations that can form the basis of strong emergent capabilities and an ecosystem-level competitive advantage. Dynamic capabilities are not necessarily bound to the level of the enterprise. Instead they may be an emergent phenomenon at ecosystem level, and the enterprise's ability to leverage these capabilities may depend on its participation in that ecosystem and the coevolution of the enterprise and the ecosystem's capabilities.

9. Conclusions and opportunities for further research

Our analysis is intended to provide a more theoretically complete picture of dynamic capabilities' foundations and roles; to also challenge some viewpoints on dynamic capabilities; to contribute to analysis of the emergence and consequences of dynamic capabilities across levels; and to raise questions requiring theoretical attention. The dynamic capabilities framework has indeed drawn profitably from economic theory, but it has also had to develop new concepts and principles to deal with problems in strategic management to which economic theory turns a blind eye, or to which it is hostile.

The key notion of emergence helps disentangle some confusion over the nature and role of dynamic capabilities and their place in strategic management. It provides a basis for rejection of the reductionist view of dynamic capabilities as simple routines or rules. Dynamic capabilities have properties that are distinct from routines and simple rules, they emerge from managerial agency embedded in entrepreneurial behaviors creating new paths (Teece, 2012). Emergence also helps to illustrate and clarify the relationship between dynamic capabilities and the entrepreneur or entrepreneurial management; indeed it helps show that the framework can easily be conceptualized as one that embraces entrepreneurial activity by management as an essential element of dynamic capabilities.

Emergence also helps clarify and reinforce the nature and roles of complementary assets and rules in this context. This line of analysis also suggests that reframing the status of the firm as living in an ecosystem (rather than a loosely defined industry or business environment) may yield analytical benefits. Instead of the firm reacting to a given environment, the emergent picture of the ecosystem is that of vibrant, complex, interactive, coevolving relationships involving the firm and other agents. We believe that the process of the emergence of dynamic capabilities itself is a contingency phenomenon varying substantially with respect to the activities and interactions undertaken. There are a number of questions and future lines of research that this perspective encourages, inter alia:

(1) Emergence and the microfoundations of dynamic capabilities; the role of emergence could be a useful frame of reference with which to approach relations between dynamic capabilities and their microfoundations. Are capabilities the emergent outcome of the microfoundations and their interaction? If so, how? Are some microfoundations dominant or more influential than others? Do the microfoundations complement each other or conflict?

(2) Modes of emergence of dynamic capabilities; how do dynamic capabilities emerge and how are they combined and integrated in organizations? Does this happen simultaneously, sequentially, or through a process of iteration that includes upwards and downwards causation? Do dynamic capabilities display a high degree of path dependence and variety or are they equifinal? If heterogeneous dynamic capabilities do emerge where firms start with similar endowments, is it a consequence of discrete triggers or a process of creeping increments and accretion?

(3) dynamic capabilities emergence and organization design; as far as organization design is concerned, how closely does emergence of capabilities through the levels correspond to the layers laid down by organization design? Do emergent concepts within organizations track organization design, or does organization design track emergent concepts, or do they co-evolve? Does emergence also apply to search processes at higher levels of analysis? If search can be non-local (or a combination of local and non-local) at enterprise level, does it follow patterns, and if so, how are these patterns formed and what do they look like?

(4) dynamic capabilities and emergence in complex ecosystems; there are also a number of essential but still unexplored questions at ecosystem level. How do individual dynamic capabilities fit with one another in a complex ecosystem? Where do dynamic capabilities at ecosystem level come from, what form do they take, and what role do dynamic capabilities play in improving ecosystem competiveness? Are sensing, seizing and transforming capabilities distributed through the ecosystem or do they tend to cluster within groups of enterprises or a single leading enterprise? Generally, if dynamic capabilities are orchestrated, does the orchestration follow a pattern, if so how does this evolve, and do the patterns differ between firms and ecosystems?

Do complementarities tend to follow a particular pattern in ecosystems or are they differentiated, if so is this related to the nature and variety of business model diffusion and imitability in the ecosystem? There is also the question of the possible role of complementarities between, and co-evolution of, ecosystem participants. The key here is a switch of emphasis (where appropriate) from enterprise/environment as naturally hostile, to one of enterprise/ecosystem relations as interdependent and mutually beneficial.

These are just some of the issues and questions that might be encouraged by pursuing the role of emergence in dynamic capabilities. At the very least we hope that it suggests possibilities through which the dynamic capabilities framework can be developed and adapted to take advantage of rich opportunities afforded by emergence-oriented research.

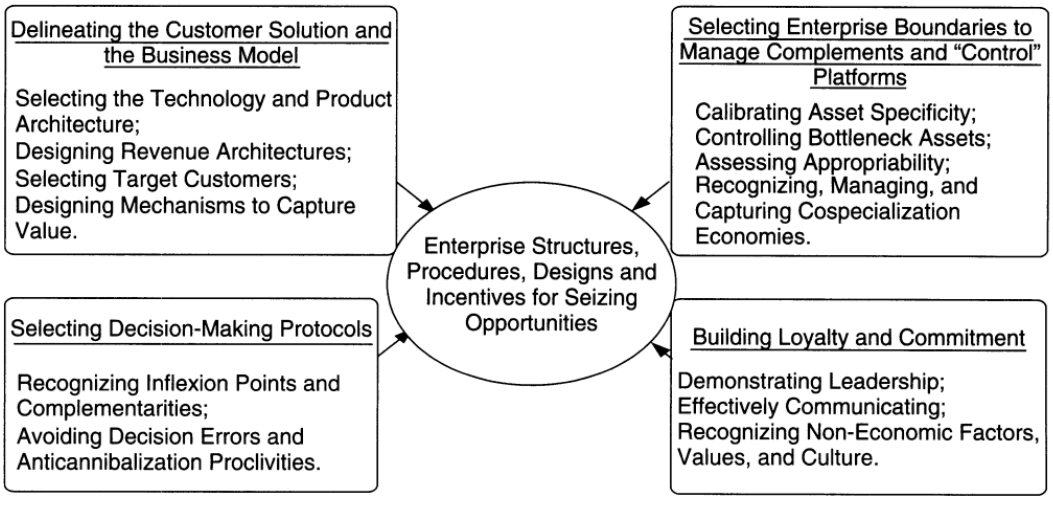

Figure 1: Strategic decisions skills/execution
(source: Teece 2007, p. 1334)

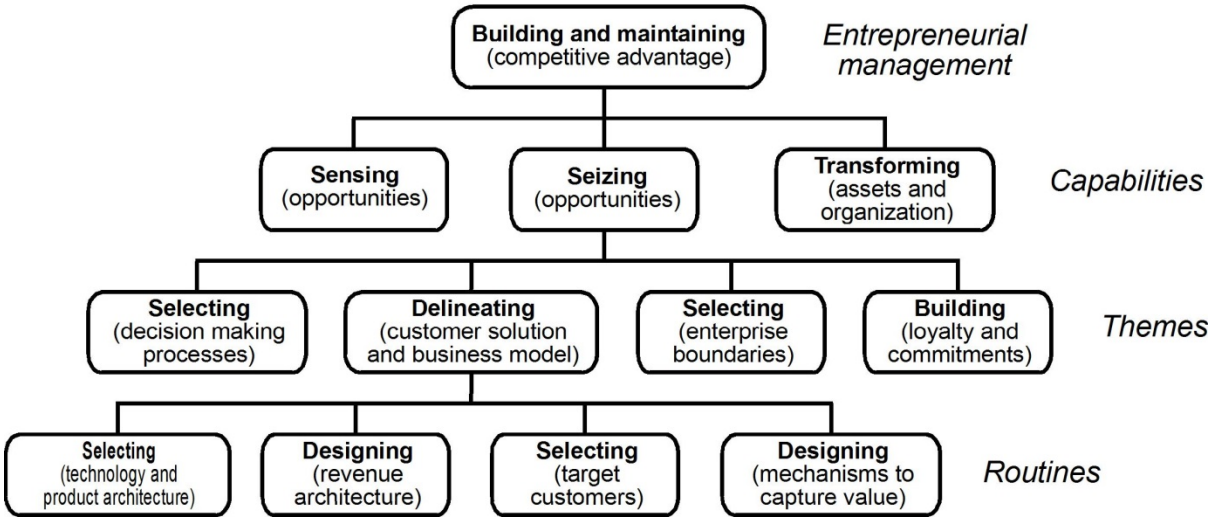

Figure 2: The roots of competitive advantage: selected building blocks (organizational processes)
(adapted from Teece 1997 and Figure 1 here)

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