

Emerging Technology: Toward a Conceptual Definition

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Abstract—Emerging Technology (ET) is a widely popular concept among scholars and business-minded people; however, ET lacks a reach and multidimensional definition. This paper reports on the investigation of the ET' definition as it is practiced in management and organizational studies in the context of digital transformation. This investigation applied a four step multimethod qualitative design which incorporates elements of literature review' and content analysis' techniques for development of the ET definition. As a result, the ET becomes a multidimensional and multilevel concept composed of social characteristics (i.e., leverage, ascendancy, ambivalence, and materiality) as well as artificial (i.e., radical novelty, fast growth, prominent impact, ambiguity), and temporal ones (i.e., ex-post and ex-ante) while applied to individual- and unit-level social structures (i.e., group, firm, cluster, and industrial sector). Consequently, ET may be used in the investigation of technologically-related social processes and mechanisms (e.g., a strategic decision support, innovation cluster positioning). Further efforts will investigate these characteristics' attributes and borderline cases in order to formulate ready-to-use framework.

Index Terms—Concept development, emerging technology definition, multimethod qualitative design.

I. INTRODUCTION

As an abstract entity, the concept plays an important role in everyday' life. In research however, the concept is a useful mental model and method for gaining knowledge during the investigation of social, artificial and natural phenomena. Moreover, concept and construct play an important role in management and organization studies (MOS) as the building-blocks of theory development [1]. In these domains, calls from editorial teams in regard to the importance of well-defined concept [2], [3] reinforce the long-standing tradition of attention to various concept's attributes [4], [5]. Thus, a clear and well-articulated definition of the concept aids to avoid their proliferation [6], [7], facilitates their operationalization during empirical evaluations. Moreover, an incomplete concept contributes to the inconclusive results, increases the confusion among researchers and unfavorable perception of scientific endeavor in the public' eye [8], [9].

On the other hand, technologies in general (i.e., including information technologies) play a growing role in contemporary society regardless of geographical locations or socioeconomic status of involved actors. Known under the generic name of digital transformation [10], the technological impacts wonder, worry, and excite researchers, elected official and business-minded people [11-14]. At the same

time, the notion of emergent technology (ET) circulates in research circles and public spheres since many decades [15]-[17]. Meanwhile, the technology and innovation management literature considers ET mostly from an operational and narrow-focused view [18], [19]. Therefore, this conflicting mosaic of facts and trends presents an opportunity for clarifying Emerging Technology as a concept. Consequently, the aim of the investigation reported in this paper is to develop the definition of emergent technology, its constitutive characteristics and dimensions.

This paper includes the following sections. After detailing an overall approach (i.e., a development of concept' definition according to established method and best-practice techniques), the ET' definition as multidimensional (i.e., artificial, social and temporal) and multilevel (i.e., individual- and unit-level) is presented and discussed. Finally, concluding section elucidates implications and future works.

II. APPROACH

An overall approach belongs to the multimethod qualitative research [20] and targets a clear and sharp definition of ET according to guidelines in [21] whose authors proposed a four step method: (a) identification of potential characteristics, (b) their organization by categories, (c) articulation of preliminary definition, and (d) refinement of the definition.

The combination of narrative literature review' and content analysis' elements [22], [23] serves to analyze a list of 24 peer-reviewed journal articles and conference papers. This list is a result of topic-based search with keywords "emerg* technolog*" within all available databases provided by SCOPUS, WOS, EBSCO, and ProQuest during the months of March and April of 2018. A subsequent application of exclusion criteria (i.e., not focus on the concept of ET; not peer-reviewed) to the titles, abstracts and authors keywords reduces the initial number of papers from 242 to 24. An additional backward and forward citation search produces 26 articles serving for the identification of ET definition. The overwhelming majority of these papers covers a period between 2015 and 2018. Among the final 50 papers, two were identified as potential candidates to articulate an ET's initial definition. This initial definition serves to analyze the rest of papers from final collection and to articulate the definition of ET.

III. RESULTS AND DISCUSSION

A. Conceptualizing Emerging Technology

Two pivotal papers provide the initial building blocks for the definition, namely [24] and [25]. The work of [24]

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culminates a period of gradual enhancement originated primarily in technology circles where ET was linked to the specific technology [26] and became a tool for labeling purposes shared among scholars of various research subdomains. By contrast, author of [25] explores the ET concept from the point of view projected into the future possible worlds and outside of above-mentioned technology-based circles.

TABLE I: EMERGING TECHNOLOGY' DIMENSIONS

Author	Level	Temporal
[27], [28]	Artifact	Ex-ante
[29], [30], [31], [32], [33], [34]	Artifact	Ex-post
[35]	Artifact/multilevel	Ex-post
[36], [37]	Community	Ex-post
[38]	Country/nation	Ex-post
[39], [40]	Team/group; community	Ex-post
[41]	Firm/enterprise	Ex-post

Mostly agnostic from applied research, the work of [25] could be appropriate for many domains of research or fields of practice. Moreover, both of these works are complementary by nature: the work of [24] belongs to technology and applied sciences realm while the work of [25] is mostly appropriate for investigating a social realm. One consequence of adopting this position is that the ET becomes a multidimensional and multilevel concept at the same time.

Authors of [24] define ET as possessing five characteristics pertaining to the recent past or present moment of time dispersed across various domains of applied sciences and engineering. The first one, radical novelty, means that ET clearly shows a new function or implement a previously unseen basic principle for a new or existing mostly technological operation. The second, fast growth, means that ET exhibits a relatively high rate of growth and diffusion comparing to other similar technologies. The third, coherence, means that ET gains a certain catalytic 'identity' and recognition among researchers and practitioners. The fourth, prominent impact, means that ET displays some tangible and distinct effect on a specific domain or in socioeconomic sphere. Finally, uncertainty and ambiguity, means that ET future outcomes and uses are yet to be defined and established. All these features focus on and describe technology per se as it is still maturing and has a chance of becoming a mainstream or disappear from the forefront of researchers' efforts and practitioners' attention. Moreover, these characteristics pertain to the actual state of affair or the recent past across a vast multitude of domains of research and fields of practice.

In comparison, author of [25] defines ET in terms of four characteristics pointing to the future. The first, leverage, could mean the expectations, the future hopes of power or forecasted possibilities that are already engendering some activities in today's world. The second, ascendancy, encompasses the notion of the technology' realization while being a part of larger aspirations. The third, uncertainty and ambivalence, denotes that the success, the future achievements and anticipated outcomes are not guaranteed and far from certain. Finally, materiality, means that the technology already delivers some real-world prototypes,

processes, procedures or artefacts that may still be part of their future realization while considered immature by today's standards and norms. The common themes among these features is the link between actual and present real-world and the future unrealized worlds that could become one day a reality. Moreover, this aspect could mostly be restricted by social structures, such as firms or teams. Taken together, these two works join the past and the future as well as the technological and social aspects under the one umbrella. The combination of all characteristics allows to articulate the initial definition of ET as follows. The ET is a special kind of technology exhibiting core characteristics: radical novelty, fast growth, coherence, prominent impact, ambiguity as well as leverage, ascendancy, ambivalence, and materiality.

TABLE II: EMERGING TECHNOLOGY CHARACTERISTICS

Type	Features	Ex-post	Ex-ante
Artificial	Radical Novelty		
	Fast Growth		
	Coherence	7	2
	Prominent Impact		
	Ambiguity		
Social	Leverage		
	Ascendancy	6	
	Ambivalence		
	Materiality		

Note: The total number of 15 refers to papers in Table I; uniqueness of dimensions and characteristics explain the number 15.

Among other repercussions of such combination, the conceptual expansion captures the essence of phenomenon, enlarges its boundaries (i.e., past, present, future vs social and technological or artificial), and unifies multiple features. Furthermore, the additional notions of time and place enhance this combination. In other words, ET may be investigated after its realization (i.e., ex-post), before (i.e., ex-ante) as well as situated at some hierarchical level of social structure (i.e., team, groups, community, firm, industrial sector, country, nation, region, and continent).

The result of application of this initial ET definition are presented in Table I. Some observation from this table are worth to mention. The multilevel facets of diversified social aspect contrasts with the uniqueness of artificial aspect in most cases (i.e., team, community, group, firm, enterprise, country vs artifact). The absent from the list is the individual level which may mean that it takes at least a team of two persons to conjure an ET. The additional operation on the initial definition of ET consists of situating characteristics with regard to the time dimension (see Table II). Among the characteristics, the vast majority belongs to the ex-post and only two to ex-ante (13 of 15). In regard to the social and artificial types, the vast majority of researchers are interested in the present and recent past of ET while the future and prediction are yet to be investigated. The same can be said to some degree about the predominance of the artificial aspect over the social ones (9 vs 6). This may mean that the nascent technology exhibits a greater fluidity and indetermination while including in its core some persistent features, components and relationships.

B. Defining Emerging Technology

The enhancement of the initial definition of ET with time

dimension helps to produce the ET definition which is as the following (see Fig. 1 for visual representation). Emerging Technology is a particular kind of technology showing the combination of social (i.e., leverage, ascendancy, ambivalence, and materiality) and artificial (i.e., radical novelty, fast growth, coherence, prominent impact, and ambiguity) characteristics in regard to the desired time span.

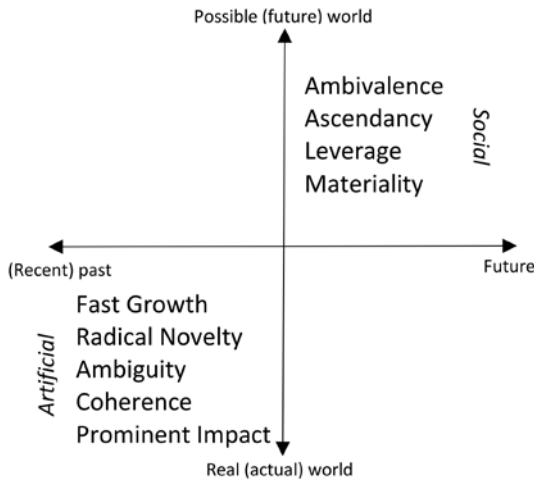


Fig. 1. Emerging Technology at a glance.

Moreover, usually started with some artificial aspect, ET may display all of them in some shape and form for some time. Another point to elicit concerns the antecedents and consequences of ET. More specifically, among technologies preceding the ET, some acquires a partial characteristics and, once all of them are in place, a candidate technology becomes an ET per se. After this point, the ET may start losing some of its characteristics and identity, thus it may turn into something else (e.g., disappearing completely, maturing, or growing, etc.).

TABLE III: COMPARISON OF RELATED CONCEPTS

	Artificial		Social					Unit & Level	
	Fast Growth	Radical Novelty	Prominent Impact	Ambiguity	Leverage	Ascendancy	Ambivalence	Materiality	
Research Front,	M	M	Y	M	Y	Y	Y	Y	Topic
Emergent Industry	M	M	M	M	Y	M	M	Y	Sector
Emergent Research Topic,	Y	Y	Y	y	Y	N	N	N	Topic
Emerging Technology Trajectory	M	M	Y	Y	Y	M	M	M	Firm, artefact
Disruptive Technology,	Y	Y	Y	M	M	M	y	Y	Artifact
Innovation	Y	N	M	Y	M	M	Y	Y	Firm
Invention,	Y	Y	Y	M	N	M	M	M	Firm
Ambiguous Technology	M	M	M	M	Y	M	N	Y	Artifact

Legend: Y, yes; N, no; M, may be, sometime, not clear, partial, unclear, not required, not necessary; y, yes with specific nature (e.g., scientific impact).

TABLE IV: COMPARATIVE ANALYSIS OF ET AND RELATED CONCEPTS

	Certitude		Vagueness
	Positive	Negative	
Research Front		Emerging Research Topic	Emerging Industry, Emerging Technology Trajectory, Ambiguous Technology
Innovation, Disruptive Technology		Ambiguous Technology, Innovation, Invention	Invention
Emerging Industry, Emerging Research Topic, Emerging Technology Trajectory, Invention			Disruptive Technology
	Ambiguous Technology		Research Front, Innovation

Note: top-down descent order of positive (i.e., yes), negative (i.e., no), and vagueness (i.e., not clear, uncertain, may be, etc.); Emerging Industry, Emerging Technology Trajectory, Research Front, Disruptive Technology are absent from Negative type while Emerging Research Topic from Vagueness type.

Another question to clarify is the level to which they may apply to (i.e., individual vs. units according to [42]). Given the interpretation of characteristics, all of them may be appropriate at the individual and unit levels. This is to say that an individual (i.e., a human being is a social actor) may consider an ET as holding some leverage, as if it is being in the process of realization whose outcomes may not be successful, but belonging to intentional and collective efforts. This social actor may attribute to artifact some degree of uncertainty even if existing procedures make an ET effects tangible in real world. The same can be advanced for a team, or group, as well as a community, firm or enterprise as an example of unit-level. For the moment, it is not clear if the notion of state, and nation fits into this definition. However, it would be prudent to constrain the proposed definition to the MOS, therefore avoiding the stretching of ET concept [21].

To clearly define the concept also means to situate it among other closely related or similar concepts. Table III presents a comparison of the ET and other concepts by using definition' characteristics and levels. Some observations from this table are as follows. ET is essentially dissimilar from research front [43], emergent industry [44], emergence and emergent research topic [45], emerging technology trajectory [46], disruptive technology [47], innovation [48], invention [49], and ambiguous technology [50]. In each paper, authors are specific about the features of related concepts and distinguish them from emergent technology. In other words, although the specific characteristics and examples of emerging technology are used in each case, the frontier between emerging technology and other concepts is clearly articulated. Moreover, the concept of ET may be appropriate at multiple levels (e.g., firm, industrial sector). Furthermore, the absence of individual level and small group level is striking although emergent technology per se might be firstly accepted in a small team context. In other words, the individual person may consider a candidate ET (i.e., a nascent phase), but only a team' decision to accept, label and

use a candidate ET as the ET makes it so. The implicit assumptions of the above mentioned statements are that all of the characteristics are not contradictory, nor overlapping as well as they all are necessary and sometimes sufficient for ET to be identified as such.

Table III serves as the basis for the comparative analysis of ET and related concepts in terms of certitude (i.e., negative or positive) and vagueness about their similarities and differences. In other words, given the definition of ET, what are the degrees of positive or negative assurance and confidence about the related ones? Table IV provides a possible answers to this question. The distinction between ET and Research Front is the least pronounced (i.e., the involved parties may agree on the features of both even where and when the subject is vague). The negative certitude about a set of mostly same concepts goes hand in hand with their vagueness, namely Emerging Industry, Emerging Technology Trajectory, and Ambiguous Technology. Furthermore, Disruptive Technology is in the middle of the pack in regard to the positive certitude and vagueness. Moreover, the absent from a negative certitude' Emerging Industry and Emergent Technology Trajectory are on the top of vagueness list. Overall, ET and its neighbors present an uneven and disparate picture where to draw a line between them is hardly possible. On the positive side, this overall blurry picture points to the numerous opportunities for further investigation.

A part of particular vocabulary apparatuses and rhetoric used by researchers and practitioners across domains and fields, what could explain these disparities and proliferations seen in Tables III and IV? Instead of asking about ET aiming to identify in descriptive terms what distinguish ET from its neighbors, one may wonder whether more fundamental and constitutive forces and mechanisms have been giving rise to ET and closely related phenomena. Specifically, (a) underlying various (e.g., social and technological) processes and mechanisms may generate events, activate actions and produce discourses; (b) these processes and mechanisms might be responsible for multiple realizations which manifest as closely related phenomena in the eye of researchers and practitioners; and (c) given multilevel nature of ET, these mechanisms may be mostly similar, although a minimal one may encompasses their most basic entities, closely related features and associated activities [51], [52].

One other point is worth to mention in regard to the ET and related concepts, namely the structure of relationship between components and interactions underpinning them, as this proliferation might be explained by various research strategies ranging from aggregation to integration [53]. In this regard, various actors, activities, processes, and events could be conceptualized as the continuum where and when the dominance (i.e., the presence and prevalence) of one of them (or their small group) capture something unique, specific and context-dependent. For example, the possible dominance of interactions over components might explain why Emerging Technology Trajectory, Disruptive Technology, and ET might share the similar behaviors.

Finally, it is worth to clarify the distinctions between certainty, vagueness, ambiguity, and ambivalence. Although

they seem to be interchangeable elsewhere (e.g., confounding is clearly observed in [54], [55]), in the current case they all pertain to different and distinct notions that play a crucial role as a glue holding together the whole descriptive definition of ET. Firstly, the certainty forms a basic foundation, a building block for ways of acting, of behaving in a particular manner given some circumstances. Understood as certitude disposed to be supported in some cases by a facts, evidence, and mostly common sense, the certainty comes before anything else as creating a scaffolding to derive views, rules, assurances, and confidences to rely on for an eventual action and activity. From this perspective, the certainty is more about the requirements for meaningful judgements to be possible. Additionally, the certainty is a necessary for creating and establishing an implicit know-how of acting and is alluding to a specific expertise. This implicit know-how may one day justify and support a manifestation of more formal rules and procedures. On a personal level, the certainty denotes the attitude toward real-world object in order to act upon. For example, a city dweller usually shows a routinized actions and activities, a kind of habits that are based on a multitude of certainties often unspeakable, unconscious, and invisible while forming a system of beliefs supporting such activities. Once a person found in a completely new environment by the choice (e.g., a travel) or by a force (e.g., a natural disaster), this disrupted fabric of certainties manifests by a change in behavior and takes a time to rebuild [56].

As for the vagueness, it should not be considered in the linguistic or rhetorical sense as the scarcity or omission of appropriate word or term [57], [58]. Rather, the vagueness relates to the real world object and denotes the lack of boundaries, the absence of a sharp demarcation of its properties, components and relations. The distinctive feature of vagueness is the presence of borderline cases (e.g., [59], [60]) where and when a gradual transition in the behavior and features combined with the variations of its components and overall environment preclude to draw a sharp and crisp boundary [61]. An illustrative example would be the distinction between a mountain and an adjacent valley: the frontier between them is hard to establish once socio-historical and biological indicators are eliminated from consideration [62].

In regard to the ambiguity, it denotes the multiplicity and profusion of interpretations, the lack of specificity, an impossibility or great difficulty to categorize and classify [63], [64]. Lastly, the ambivalence describes the inner imprecision about future possibilities; it expresses possible contradictions, conflicts and oppositions in views, attitudes, and intentions [65], [66]. To summarize, the certainty is about actions and activities which are directed toward a vague object or thing. This object could be ambiguous (i.e., already realized and existing in real world) or ambivalent (i.e., to be realized in the future). In other words, the human certainty of social actors defines their actions and activities in regard to the objects constituting a core element of technology. This object might be described as ambiguous if the technological prototypes incorporating these objects are already giving some real and discernable attraction in social

and economic spheres; otherwise, these objects may be ambivalent because of the conflicting promises they potentially behold.

IV. CONCLUSION

This concept development paper aims to clarify the definition of Emerging Technology according to the guidelines outlined in [21] in the context of management studies and pertaining to the rapid digitally supported technological change affecting many spheres and levels of society. As a multilevel and multidimensional concept, ET includes characteristics combining three dimensions: the social (i.e., leverage, ascendancy, ambivalence, and materiality), artificial (i.e., radical novelty, fast growth, prominent impact, and ambiguity) and temporal (i.e., ex-post, ex-ante). While artificial elements are already occurred in the recent past, the social ones may materialize in the future. All of them may be attached to the individual- and unit-levels (i.e., groups, and firms). Seen from this angle, ET is different from similar concepts (i.e., research front, emergent industry, emerging research, disruptive technology, innovation, invention, and ambiguous technology). Although difficult to surely distinguish between them, underlying social and technological mechanisms and forces may account for all.

This richness of characteristics may help researchers in investigating innovative enterprises and professional practices where and when diverse technologies (i.e., including information technologies) play a crucial role. Moreover, policy-makers and business-oriented people may find it useful for guiding their decision making. Specifically, an ET concept may help choosing wisely an appropriate strategy for positioning a start-up in local and global markets [67]. Another example where and when ET may enhance existing research and practice concerns the regional innovative cluster' development as a part of city-level capabilities [68] or amplifying local conditions for emerging industrial clusters [69].

In order to achieve a full potential as a mature concept and construct, ET concept requires however further efforts. These efforts may continue with the guidelines outlined in [19] or adopt another approaches (e.g., [70], [71]). In all cases, these efforts need to clarify characteristic' attributes and their values in qualitative and quantitative terms according to the criteria outlined for example in [72]. In the same vein, these efforts need to elucidate the relationship between dimensions in order to avoid overlaps and contradictions. Furthermore, these efforts necessitate to identify borderline cases (i.e., conceptual and contextual boundaries according to [73]) as well as approaches and methods of its practical application (e.g., frameworks and ready-to-use guidelines).

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