
Article:
Abatecola, G., Breslin, D. orcid.org/0000-0001-8309-7095 and Kask, J. (2020) Do organizations really co-evolve? Problematizing co-evolutionary change in management and organization studies. Technological Forecasting and Social Change, 155. 119964. ISSN 0040-1625

https://doi.org/10.1016/j.techfore.2020.119964

Technological Forecasting and Social Change
Volume 155, June 2020, https://doi.org/10.1016/j.techfore.2020.119964

Do Organizations Really Co-Evolve? Problematizing Co-Evolutionary Change in Management and Organization Studies

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Abstract

This conceptual article discusses and, from some aspects, also problematizes the *state-of-the-art* regarding co-evolutionary research in Management and Organization Studies (MOS). Analyzing 76 characteristic studies published since 2000, we address three simple, significant questions: What co-evolves? What causal relationships are considered? What are the theoretical processes? The motivation behind our contribution is twofold: on the one hand, the turn of the century witnessed the remarkable growth of inquiries which, at face value, have claimed to be "co-evolutionary"; but, on the other hand, specific analyses about *where* this fast-growing meta-theoretical perspective on social change is now, and *where* it could move towards in the future, are still missing in MOS. Our study reveals increasing heterogeneity in defining what co-evolves and the associated causal relationships. It also reveals the prevailing scarcity in explaining what processes substantially characterize co-evolution in MOS. With a view to shaping the future direction of research in this area, we propose four core principles that theoretically set the co-evolutionary project apart.

Keywords: co-evolution; adaptation; management; organization; change; conceptual

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Do Organizations Really Co-Evolve? Problematizing Co-Evolutionary Change in Management and Organization Studies

1. Introduction

What is the *state-of-the-art* regarding co-evolutionary research in Management and Organization Studies (hereafter MOS)? What conceptual and/or methodological challenges can we identify? Since their inception in the late 1980s, co-evolutionary accounts in social sciences have been mostly positioned within the *organizational evolution* (Nelson and Winter, 1982) parental domain; a domain which, generally speaking, can be considered as the stream of research that, although at different points of adoption, has been influenced by Charles Darwin's *The Origin of Species* (1859) and also by its doubtless – although still controversial from some aspects – impact on theory in MOS (Durand, 2006).

On this premise, the turn of the century has indisputably witnessed the remarkable growth of MOS inquiries which, at face value, have claimed to be "co-evolutionary" in their inner nature. This growth definitely seems to be consolidated to date, especially if we consider the number of articles most recently published in top MOS journals, and their various subfields, such as general management (Van Driel et al., 2015), organization theory (Levinthal and Marino, 2015; Simsek et al., 2015), marketing (Ozuem et al., 2017), leadership (Spisak et al., 2015), innovation (Avila-Robinson et al., 2019; Volberda et al., 2014), technology (Grodal et al., 2015; Jacob and Duysters, 2017), and evolutionary economics (Almudi et al., 2017a).

On the basis of the above, an increasing number of scholars currently maintain that a well-balanced MOS theory of co-evolution can constitute a research perspective, which is useful not only to social scientists in particular but also to business practitioners and policy makers more in general, for appropriately interpreting the multiple problems witnessed, at both the macro and microeconomic level, in the international landscape. In particular, in contrast to many of

the conventional perspectives existing in theories in MOS, co-evolutionary researchers argue that these problems cannot be exhaustively studied through focalizing on firms, or their environments, as separate and fixed units of analysis. On the contrary, they believe that circular, dialectical, and multi-level perspectives can more properly support social organizations in their continuous adaptation to the global scenario (Cafferata, 2016; Cattani et al., 2017; Jones and Walter, 2017; McCarthy et al., 2017; Sandhu and Kulik, 2019).

This introduced, the main contribution of our conceptual article is that it aims to critically discuss and, from more than one conceptual and methodological aspect, also problematize the current *status* of co-evolutionary research in MOS. The motivation behind the article is twofold: on the one hand, as we have anticipated, it seems that co-evolution is becoming a fast-growing meta-theoretical perspective used by scholars to explain social change; but, on the other hand, although also recently claimed (Alexander and Price, 2012; Belussi, 2018; Busseniers, 2017; Grandinetti, 2018; Hodgson, 2013), specific analyses about *where* this perspective is now, and *where* it could move towards in the (near) future, are still missing, at least to our knowledge, in MOS.

We show that there is a great deal of heterogeneity in co-evolutionary studies in management and organization, with ambiguity in terms of how scholars have defined units of analysis and conceptualized processes of co-evolution. We propose four core principles that theoretically set the co-evolutionary project apart. *First*, we argue that the co-evolving entities, or what evolves, need to be represented as a dualism of coding and effect. Whilst coding retains information that is inherited across multiple evolutionary events, effect is the outward expression of that information to the outside world. *Second*, co-evolution includes multiple levels of organization, from individual and group to organization and society (Lewin and Volberda, 1999). *Third*, at each level, evolution occurs through the mechanisms of variation, selection and retention that act on

the dualism of coding and effect (Campbell, 1965). Finally, *fourth*, the relationship between co-evolving entities is *specific*, *reciprocal* and *simultaneous* (Janzen, 1980).

In light of the aims explained above, the remainder of the article is organized as follows: first, we introduce its theoretical background, constituted by some traditional definitions of co-evolution in biology and some conceptual conjectures of that co-evolution initially proposed by the MOS research community in the past century. Second, with this constituting the core of our research, we choose the new century to focus on the diffusion of co-evolutionary accounts in MOS. In this regard, we analyze 76 representative publications on the topic published since 2000 and critically discuss them through three simple, yet meaningful, research questions: What co-evolves? What causal relationships are considered? What are the theoretical processes? We then propose four theoretical principles, which, we argue, set the co-evolutionary project apart from other approaches in this area. Implications and conclusions bring our intended contribution to a close.

2. Theoretical background

The word *co-evolution* is composed of two parts, the prefix "co" and the main word "evolution". The meaning of the prefix "co" is easily understandable and generally states that two (or more) parties are somehow interrelated; for example, they do something together (e.g., co-existence, co-authorship, co-ownership, or, as in our case, co-evolution). The word "evolution", instead, comes from Latin and substantially means "to roll forward". Since Charles Darwin's influential *Origin of Species* (1859), in biology evolution has, over time, been generally conceived as the occurring consequence of three key intertwined processes (Koonin, 2012; Thompson, 2013): *i) Variation* of the instructions in an entity's underlying coding attributes (i.e., genes or DNA), *ii) Selection* of the associated outward effects directed by the coding, and *iii) Retention* of the underlying coding attributes (hereafter VSR).

As known, the coding (e.g., *genotype*) is inherited and prospectively inheritable, while the effect (e.g., *phenotype*) is the developmental manifestation of the coding in a specific environment. Following the same dualism, some social scientists have used the term *replicator* for the coding, and defined it as anything of which copies are made, and *interactor* for the directed entities that interact in a way that causes differential replication of its instructions (Dawkins, 1976; Hull, 1988). Although, in this paper, from here on, we use the generic terms of *coding* and *effect* to represent this dualism.

On this premise, in biology, co-evolution has, over time, been developmentally conceived as the reciprocal genetic change that occurs between two species as they interact with each other (Ehrlich and Raven, 1964; Thompson, 1982). Its key feature is that the selective factor that "stimulates evolution in one species is itself responsive to that evolution" (Futuyma and Slatkin, 1983: 6). In other words, co-evolution is the evolution of two or more species through the action of reciprocal selective pressures and adaptation between them, as each has a causal influence on the other's evolution (Kallis, 2007). Each of the reciprocally linked evolutionary species has the potential to change the selection regime experienced by the other. Thus, co-evolution is reciprocal genetic change in different, interacting species.

From the natural realm, various cases can be drawn to illustrate what has been introduced above. For instance, antagonistic co-evolution is said to occur when two co-evolving species evolve over time through conflicting, hostile relationships (Thompson, 1982). In general, we have one entity trying to dispatch a second and the latter, in turn, trying to avoid the former. This kind of relationship includes interactions such as predator-prey or parasite-host. Selection processes act on both parties over time, increasing their ability to find preys/hosts or avoid predators/parasites, respectively. Among the so-called *brood* parasitism, for example, some parasitic birds (e.g., some ducks) can evolve through learning how to deposit their eggs in the nests of other host birds. When this happens, the parasitic birds have more time to devote to

primary survival activities, such as searching for food, than the host birds; the latter, in fact, have to take care of an increased number of new-born birds. At the same time, in contrast, the host birds can counter-evolve through learning how to distinguish their new-born birds from those of the others, thus defending themselves from parasitism.

This explained, in its strictest biological sense co-evolution involves the contemporaneous satisfaction of the following three principles (Janzen, 1980): *i) specificity*, i.e., the evolution of a coding attribute in one species is caused by the other species; *ii) reciprocity*, i.e., coding attributes evolve in both species as a result of the other; and *iii) simultaneity*, i.e., coding attributes evolve in both species at the same time. Abstracting these three principles from biology to a comprehensive meaning, *specificity* defines that change in entity A is caused by entity B; *reciprocity* implies that entities A and B are causally interdependent, thus meaning that while B causes change to A, A also causes change to B; and *simultaneity* defines that the bi-directional causation takes place in tandem, thus it is not sequential or, in any other way, separated in time. In sum, for a process to be strictly defined as co-evolutionary in biology, all these three principles must be met.

Following on from this, the study of co-evolution in MOS began over three decades ago. In MOS, we could argue, co-evolution mostly draws on the *circular* (Weick, 1969) and *dialectical* (Benson, 1977) approaches to the study of the organization/environment relationship, and attempts to solve the overarching determinism/voluntarism dichotomy in this relationship.

At the very beginning, the unit of analysis mostly investigated is the organizational unit as a whole, and co-evolution is commonly perceived as a process constituted by the combined and dynamic effect of strategic voluntarism, environmental and institutional pressures/constraints. In this regard, for example, in an initial theoretical framework on the topic, Lewin and Volberda (1999) propose some properties characterizing a co-evolutionary process in management and organization theory: first, multi-levelness is key, with co-evolution conceived as “macro” when

regarding the organization/environment relationship, and "micro" when regarding the resource/capability relationship within organizations. Second, co-evolution happens through interdependence and mutual feedback: it is "direct" when it concerns the mutual evolution of two populations, while "diffuse" when it concerns the evolution of a broader eco-system in terms of actors.

In parallel, we could also acknowledge that early accounts in MOS have also attempted to theoretically explain the dynamics of co-evolution through the evolutionary VSR mechanism. Baum and Singh (1994), for instance, initially distinguish the theoretical constructs of "genealogical" and "ecological" hierarchy within/between systems: the former is basically internal, i.e., it is substantively associated with the implementation and selection of corporate capabilities based on the firm's previous knowledge; in contrast, the latter is essentially external, i.e., it is mostly associated with the implementation and selection of corporate capabilities through their mutual relationships with the outside context. Baum and Singh (1994) argue that these hierarchies are continually entwined, with the adaptation (or failure) of firms ultimately as the consequence of their interdependence ([1]). The firms *selected in* are only those that can accomplish this twofold process.

With all this explained, to date it seems that the "big picture" around co-evolutionary research in the management community is much wider than it was at the beginning. In particular, a computer-based search, through the abstracts' keywords "coevol*" OR "co-evol*", recently conducted through key journal articles' databases for social sciences, suggests that the use of the co-evolutionary perspective in MOS has significantly increased during this new century. In

([1]) Murmann (2003) seems particularly explanatory here, investigating the evolution of the synthetic dye industry, from 1856 to World War I, through combining the industry, technology and country perspectives. Specifically, he first explicates how the industry and its institutional environment could be conceived as two populations evolving through VSR. Then he explains how their mutual relationships impact on the evolution of each of them when regarded separately.

addition, as we explain in the following analysis, this picture also seems much more complex from many aspects.

3. Analysis

Table 1 summarizes, in increasing chronological order, a number of representative works about co-evolution in MOS (and their sub-areas) published since 2000. We built the table on the basis of our research background/profile/interests and, in particular, on our previous knowledge about the included works. Thus, with no aim of being exhaustive in terms of existing literature on the topic, the table highlights distinctive features such as the methodology adopted in the listed studies and their major area of investigation.

[INSERT TABLE 1 ABOUT HERE]

In principle, from Table 1 we can highlight some initial descriptive statistics. Specifically, our analyzed sample is composed of 76 works, with 97% consisting of articles published in journals classified in the *2018 ABS list*. General management and organization studies represent the most investigated areas in the sample (22% and 18%, respectively), followed by economics, marketing, social sciences, and innovation (14%, 11%, 11% and 8%, respectively). Quite surprisingly, studies formally falling in the strategy area only account for 5% of the sample, which, in an even more limited weight, also comprises works in the areas of business history, international business, entrepreneurship, sector studies, and operations and technology.

On this premise, more than half of the studies in the sample are conceptual (N=44, i.e., 58%), with some of them also specifically adopting simulation modeling techniques (e.g., Almudi et al., 2017b; Levinthal and Marino, 2015). Instead, as far as the empirical analyses are concerned, qualitative methods largely prevail (N=28, i.e., 37%), while quantitative or mixed methods are

substantially very scant (4% and 1%, respectively). On this basis, qualitative methods are largely composed of single or multiple longitudinal case analyses at firm level, although some longitudinal analyses at industry level (e.g., Murmann, 2013) are also present. The time observations in the qualitative studies are particularly heterogeneous, ranging from a few years (e.g., Uli, 2018a) to even centuries (e.g., Van Driel et al., 2015). Their settings are heterogeneous too, with geographical areas comprising – to date – a number of countries in Europe, North and South America, and Asia; furthermore, the industry contexts vary accordingly, with financial services, Formula One Racing, shipbuilding, microfinance, entertainment, tourism, personal computers, energy, sustainable mobility, and telecommunications constituting only some among the many extant examples.

Drawing on the preliminary evidence above, a number of key conceptual and methodological issues seemingly come to the fore. In this regard, while Table 1 already offers a summary of our collected evidence, in the next subsections we provide readers with a more thorough account around our introduced research questions, i.e., investigating units of analysis, causal relationships and theoretical underpinnings of recent co-evolutionary accounts in MOS.

3.1. What co-evolves?

Table 2 specifically shows our elaborated evidence around this first question, with rows representing the analytical levels used, and columns showing the different types of coding and/or effect attributes in use (as well as columns for ambiguous concepts/variables that cannot be classified as either coding or effect). As the table apparently suggests, huge heterogeneity currently prevails, with the co-evolving units of analysis in the investigated publications representing, at least, six different organizational levels (i.e., from individuals to communities).

[INSERT TABLE 2 ABOUT HERE]

At the bottom of the multi-level hierarchy in Table 2, we find research on how the characteristics and behaviors of humans (for instance, of entrepreneurs) are the focal units of analysis that co-evolve (Jones, 2001; Macpherson and Holt, 2007; Waring, 2010). One step up, we show, for example, how the routines of a group of people within an organization co-evolve (Levinthal and Marino, 2015). At the third level, features or possessions of firms and other organizations are some co-evolutionary accounts' units of analysis, meaning, for example, how firms' capabilities (Huygens et al., 2001; Jacobides and Winter, 2005) or businesses' form and function (Rindova and Kotha, 2001; Clarke et al., 2014) co-evolve.

As organizations cooperate in inter-organizational networks, the networks themselves are a fourth level of analysis. For example, in Ford (2011), network activities, network routines and roles in networks are intertwined in co-evolution. Similarly, in Koza et al. (2011), the multinational holding group, a network of multiple national organizations, is one part that co-evolves, while Weber (2017) focuses on interfirm governance features.

Zooming further out, Volberda et al. (2001; 2014), for instance, investigate how whole industries/markets co-evolve in relation to other entities at lower/higher levels of analysis. Finally, beyond the industry level, we have studies which have taken the whole regulatory environment (Flier et al., 2001; Lewin and Koza, 2001) and national systems (Djelic and Quack, 2007) as co-evolving parties.

On this premise, the investigated sample shows another (and, perhaps, even more important) division of co-evolving entities and their attributes. On the one hand (i.e., *Column A* in Table 2), there are those attributes of entities that can be considered as coding, i.e., underlying instructions (e.g., regimes, discourses, norms, capabilities, preferences, orientations, routines, habits) which are responsible for particular effects – in other words, properties that code for, and instruct, enabling and constraining expressions and character traits, at least in some abstract

meaning. On the other hand (i.e., *Column B* in Table 2), there are those attributes that can be considered as effects, i.e., observable beings of the entities (e.g., designs, behaviors, activities, forms, governance, characteristics, etc.) – in other words, the realized expressions, character traits and structures which, in some sense, are directed but not independently determined, by the information in the former, and which are visible to and selected by the external environment.

On the basis of the above, and more specifically, the entity's coding and effect are seemingly related because the underlying instructions in the coding, which are responsible for particular effects, cannot themselves directly be evaluated but indirectly participate through the effects that they are instructing for. Nevertheless, the coding fulfils, in an abstract meaning, the role of "memory sticks" – comparable to the role of genes in biology – that save and transfer instructions and codes for effects from time t_0 to time t_1. Thus, drawing on the unit of selection debate (Sober and Wilson, 1994), we could maintain that, in co-evolutionary processes, the involved entity's coding and effect are linked in the following principal way: performance, fit and other qualities are evaluated on the actual observable effects (i.e., *selection of* effect), whereas longevity and spread of a particular coding are dependent on the co-evolutionary success and failure of the effect they are responsible for (i.e., *selection for* coding instructions of entities).

However, even though the coding enables and constrains potential effects, as well as including prioritization and ordering, it is essential to underline that the coding does not determine a particular effect. Co-evolving entities are not isolated from the external environment. Some codes may lay latent without being enacted, while others are enacted by triggers in the external environment or by some action taken by a related entity (Johansson and Kask, 2013). In other words, in co-evolution, there is an ongoing iteration between coding and effects in the involved entities.

Moreover, Table 2 also shows a third category (i.e., *Column C*) of co-evolving features, taken from the 76 papers we have reviewed, that cannot be related either to features coded for

action and setting potential, or strictly as realized effects. This ambiguity is, for example, represented by studies referring to industry technology, networks and environments as units in co-evolutionary processes. In these cases, it seems unclear whether these studies refer to the coding/instructive aspects, the observable effect, or both. Industry technology, for instance, might either be seen as a set of rules (coding) or an observable artifact spurred by development-seeking capabilities, routines and habits (effect). The ambiguity in defining the entities that co-evolve is problematic if one seeks to develop a conceptualization of the process of co-evolution. As noted above, two co-evolving entities mutually select variants in the other through their expression in effects, which result in the selective retention of underlying coding. This interaction between co-evolving entities is *specific*, *reciprocal* and *simultaneous* (Janzen, 1980). It is, therefore, unclear how ambiguous attributes, such as science (Arthur, 2009) or institutional environments (Van Driel et al., 2015), fit into this process (see Table 2). For example, how can "science" select anything? What specifically is doing the selecting in an institutional environment?

Finally, a fourth group (i.e., *Column "D"*) also seems vivid, consisting of various units of analysis in the present co-evolutionary accounts in MOS that could not be classified as attributes of any co-evolving entity at all but seem more to be comparative, performance variables; for instance, this is the case when studies state that (degrees of) transparency, dynamics, advantages/benefits (vis-à-vis competitors), and other variables are said to co-evolve with some entity or with another variable.

3.2. What causal relationships are considered?

When proposing theoretical conjectures about co-evolutionary processes, Baum and Singh (1994) highlight the priority of individuating and categorizing units of analysis at multiple levels. These units must represent distinct categories of *per se* evolving entities which, at the same

time, interact (i.e., co-evolve) with *per se* evolving entities at other levels. In other words, there must be a reciprocal interaction (i.e., a *two-way* effect) between the evolving entities; reciprocal interaction, as shown in Table 1, is also reflected in the majority of the studies we have considered as representative in this article.

On this premise, in MOS, the presented ambiguity in clearly defining what is co-evolving also seems to cause considerable problems when we attempt to interpret the nature of the causal relationships between and among the (supposed) co-evolving entities. Essentially, this boils down to an ontological question with regard to the independent "existence" of the investigated phenomenon. For instance, we might argue that a group exists through its routines and, in this sense, might evolve as a set of coding attributes *(A)* over time (Hull, 1988). However, what about an effect *(B)*, such as behavior, or a variable *(D)*, such as transparency? Can such ephemeral fleeting expressions and results evolve, maintaining continuity with a previous existence and, at the same time, a link to uncertain future states? Almost certainly, such effects and variables do not have a memory component that can store and pass on information and, therefore, could not be conceived as co-evolving entities without matching coding attributes (Hodgson and Knudsen, 2010).

The above paucity of conceptual explanations about the nature of causal relationships also seems to be in contrast to the significant theoretical foundations of evolutionary economists, who have mostly spearheaded the concept of evolution in MOS studies. We know, for example, that, although not exempt from criticisms (e.g., Levit et al., 2011), *Generalized Darwinists* (e.g., Aldrich et al., 2008) have abstracted concepts from biological evolution to conceptualize the processes of organizational evolution and co-evolution. In particular, some of them have not only used the general VSR mechanism to predict co-evolutionary change but also developed conceptualizations of the co-evolutionary process through the dualism of coding *(A)* and effect *(B)* in two or more related entities.

This explained, what emerges from our analysis (again evidenced in Table 1) is that, on the one hand, some of the studies close to *Generalized Darwinism* effectively use the VSR framework to conceptualize co-evolutionary processes (e.g., Murmann, 2013). However, on the other hand, most of these studies do not adopt the dualism of coding and effect (e.g., *replicator-interactor* concepts, the *genotype-phenotype*, or any related terms with the same function) to explain the causal relationship between co-evolving entities. In general, they do not seem to be clear about the theoretical mechanisms that are occurring in this relationship. Of course, this evidence seems to result in a lack of precision regarding those mechanisms of co-evolutionary change and, in this regard, a couple of different, but (conceptually) intertwined examples can be illustrative (Breslin, 2016).

First, in studying the co-evolution of technologies, Arthur (2009) conjectures a process that he calls "combinatorial". Composed of current technologies *de facto* inheriting portions of preceding technologies, this multi-level process has its most vivid origins in those phenomena, constituting its theoretical pillars, which bring human beings to design and implement working technologies. In particular, Arthur conceives technologies as *metabolisms*, in which phenomena, which he assimilates to biological coding attributes (i.e., genotypes), are designed towards an aim. The technological components, as a consequence, can be supposed as the effect type manifestation of that coding.

This introduced, the process which leads to the birth of new combinations of technologies is the result, intermediated by engineers and designers, of the concurring VSR action, with variation happening through combination. However, it does not seem totally clear what co-evolving unit Arthur (2009) is referring to and what the related coding and effect might be; or, in other words, how a co-evolving entity's coding and effect are specifically linked.

Second, and relatedly, while elaborating on knowledge creation and diffusion, Crossan et al. (2013) also introduce a co-evolutionary theorization of organizational learning; in this regard,

they propose multiple coding attributes (A) at different levels, which, for example, range from "retained learning" (seemingly knowledge) to single top decision makers (such as Mark Zuckerberg at Facebook). Such coding attributes, they maintain, can constitute selection forces at different hierarchical levels. However, this promising theorization still seems to suffer from conceptual accuracy in defining the coding, which, as written, varies from knowledge to individuals. Whilst the former knowledge might represent informational instructions that are retained over time, it is unclear what aspect of an individual would perform this same function – Genes? Traits? Habits? Moreover, the parallel identification of matching effect at each level (and, thus, also the associated relationship between the two types) also seems to require additional effort.

3.3. What are the theoretical processes?

As for our third question, while most of our sampled studies seemingly fail to offer significant theoretical accounts of the processes underpinning co-evolution, some draw from other conceptual approaches, such as system thinking (Cafferata, 2016), institutional theory (Djelic and Quack, 2007; Jones, 2001), learning theory (Levinthal and Marino, 2015; Schlaile et al., 2018a), or selection (Eyuboglu and Buja, 2007; Malerba et al., 2008). In this regard, for example, Almudi and Fatas-Villafranca (2018) introduce *promotion* as a peculiar mechanism to explain co-evolution. In particular, for promotion to occur: "(i) agents (interactors)[2] in subsystem X realize that by shaping the VSR processes in Y, they can increase the possibilities of being selected in their own domain X; and (ii) because of (i), agents in subsystem X decide to act *intentionally* in Y *by shaping* (or trying to shape) any of the Y-VSR mechanisms. The same applies for Y-agents and their actions on X" (p. 90).

(2) The term *interactor* corresponds to the term *effect* used in this article.

On this premise, in those few studies that, as written in the preceding sub-section, have adopted both the VSR mechanism, and the dualism of coding and effect, two broad approaches have seemingly been taken when developing conceptual accounts of co-evolutionary processes (Breslin, 2016). Some accounts take what we might call an "entity" approach, with, for example, the organization co-evolving as a cohesive bundle of routines (Hodgson and Knudsen, 2010). Here the codings *(A)* are collective patterns, such as routines. The related effects *(B)* of these entities are personified through the carrying groups of collectives of individuals. Both the routine and group are considered to be stable and resistant to change. The *key* interest, as a consequence, is mainly kept at the organizational level, thus above the level of individual learning. Managers, in other words, at best make choices on the basis of firms' agency.

The focus above creates problems when studying the co-evolutionary processes regarding routines, knowledge, or ideas within the organizations themselves. This is chiefly why some scholars have also deepened this "entity" approach through featuring multiple co-evolving entities for different analytical levels (Hodgson and Knudsen, 2010). For example, "the *routine-job* represents the micro-level, moving to the *organization-organization* and *species-population* at higher levels" (Breslin, 2016: 56). However, notwithstanding the multi-level essence of these proposed solutions, what remains predominant is still the intrinsic conjecture that evolving ideas, routines, memes, or knowledge are ultimately entwined with organizations, groups, and individuals (e.g., Price, 1995; Schlaile and Ehrenberger, 2016; Weeks and Galunic, 2003). In other words, effects *(B)* and the people enacting them become one and the same representation. Often, this connection has derived from conceiving firms as evolving entities, thus assuming that the integrative forces within them cause a change, which mainly takes place at the organizational level (Aldrich and Ruef, 2006).

This explained, if we, however, consider the differentiation and fragmentation within organizational cultures, then, of course, the unit of selection changes within the organizations themselves. Thus, the *selection of* these individuals/groups shifts to the *selection for* associated ideas, routines and knowledge (Hodgson and Knudsen, 2010; Rerup and Feldman, 2011); although, Witt (2004) argues that interpreting the selection process in this way softens the role played by individuals. In other words, the *selection for* routines attributes pre-eminence to the "environment" external to them; for example, routines whose performances are not high become *selected out* because managers choose different employees. At the same time, if we conceive individual decision makers as the enactors and, ultimately, "selectors" of routines through their choices, then evaluating feedback and planning scenarios becomes prominent ([3]).

While entity-based accounts, as written, focus on co-evolving structures, such as organizations, "practice-based" co-evolutionary accounts shift attention to other effects *(B)*, such as behaviors and norms. In these accounts, coding and effect are featured as a reciprocal duality (Farjoun, 2010), through cognitive schemata and visible behaviors or narratives, respectively (Feldman and Pentland, 2003). In the entity accounts, "ideas, capabilities and knowledge are viewed as repositories terminally tied to the life of individuals and groups" (Breslin, 2016: 60). In practice-based accounts, conversely, they end up as enacted through everyday behaviors; in other words, as human beings are able to learn and (eventually) change, ideas, capabilities and knowledge fight in the global "mind space" (Dobson et al., 2013).

However, most of the practice-based accounts also tend to pay attention, almost uniquely, to only one analytical level. In this regard, for example, Pentland et al. (2012) give primacy to the

([3]) To draw a parallel with similar, recent debates in evolutionary biology, Jablonka and Lamb (2014), for example, interestingly argue that natural selection and (then) evolution is primarily driven by heredity. An inheritance process, they maintain, can be both gene and non-gene based, and also behavioural or symbolic (e.g., through language).

group, whose routines evolve in a reciprocal relationship between the ostensive and performative aspects. Here, the ostensive understanding of the routine represents the coding, whilst the sets of performances seen in the performative aspect relate to the corresponding effect (Feldman and Pentland, 2003). At the same time, some scholars (e.g., Mesoudi, 2011; Price, 2012; Schlaile et al., 2018b), as we have written, have also individuated units of analysis at different levels in co-evolutionary processes. Thus, individuals and collective cognitive structures symbolize the coding at the level of the individual, group and organization, respectively. The matching effects, instead, depend on the specific context hosting the selection process, i.e., the activities made at individual, group, or organizational level.

In conclusion, we could argue that choosing an entity or practice-based approach to study co-evolutionary processes is mainly the consequence of the perspective adopted in the more general study of the organization/environment relationship. In the former approach, we mostly assume that the external environment (or, at least, that external to the investigated entity) changes more quickly than the associated individual/group. Thus, "ideas, capabilities and knowledge are selected *for*, by the selection *of* carrying individuals" (Breslin, 2016: 60).

Vice versa, in the latter approach we mostly start from the assumption that individuals/groups are able to dynamically (and, indeed, proactively) adapt to environmental change. All this means that, while multi-level co-evolutionary accounts can be put forward through both these approaches, these accounts ultimately depend on the specific perspective adopted in the long-standing and well-known dichotomy between environmental determinism and strategic voluntarism in shaping organizational adaptation and evolution. As is widely known, deterministic perspectives, such as contingency theory or population ecology, give predominance to environmental and institutional pressures; conversely, voluntarist views, such as upper echelons theory, recognize the primacy of strategic choice and the free will of firms.

4. Discussion and implications

In this article, we have focused on the evolution of co-evolutionary research in MOS in the new century, through discussing and problematizing key conceptual and methodological aspects for both current and prospective research in this field. From our side, we have sampled 76 representative publications on the topic published since 2000 and then scanned them through three simple but, we believe, meaningful research questions: What co-evolves? What causal relationships are considered? What are the theoretical processes?

As we have explained, our analysis reveals not only the constant increase in accounts within MOS which, at least formally, are labeled as "co-evolutionary" to date, but also reveals growing differentiation in terms of areas of investigation; these no longer include only general management and organization studies but also, for example, marketing, ecological and evolutionary economics, social science, and innovation studies.

Conceptual works and (multiple) longitudinal case studies largely prevail among the analyzed publications. In this regard, on the one hand, we have found huge theoretical heterogeneity, to date, in defining what units of analysis co-evolve; while, on the other hand, we have seemingly registered theoretical paucity in explicating what processes most vividly underpin co-evolution. Hence, a deeper analysis of the conceptual approaches taken apparently evidences a number of important issues that need to be resolved in developing such co-evolutionary accounts. *First*, a co-evolutionary account needs to identify what is co-evolving. We believe that a lack of clarity in both defining co-evolving entities and the relationships between these ineluctably leads to a lack of conceptual precision in the resultant theoretical accounts. *Second*, a co-evolutionary account needs to embrace a nested hierarchy of levels and identify the level(s) at which co-evolving entities exist. In other words, at what level(s) are changes assumed to happen (Dopfer et al., 2004; Farjoun, 2010; Geels, 2005; McCarthy et al., 2010). *Third*, a co-

evolutionary account needs to explain what defines the (supposed) co-evolving relationships and, in particular, the processual theories that define these relationships.

4.1. Towards a co-evolutionary theory in MOS

In response to the issues above and on the basis of our analysis of the 76 works in the dataset, we propose four core principles that theoretically set the co-evolutionary project apart from other perspectives and approaches in this area.

First, with regard to the question of what evolves, each entity involved in co-evolution needs to be represented as a *dualism of coding and effect.* As explained, the former coding retains information and knowledge (e.g., cognitive schema or organizational blueprint) that is inherited across multiple evolutionary events. The latter effect, in parallel, is the outward expression of that knowledge to the outside world (e.g., sets of behaviors or organizational structures). Crucially, for the interrelated entities A and B to co-evolve over time, there are *selection of* the effects, and *selection for* the corresponding underlying coding (Hodgson and Knudsen, 2010; Sober and Wilson, 1994), as outlined above. We believe it is also warranted to highlight the eventual time delay between coding and observable effects; to this end, for instance, future studies in MOS could investigate how effects, such as new organizational forms, occur (a)synchronously to the originating coding.

Second, co-evolution needs to include *multiple levels of analysis*, from individual and group to organization and society (Levinthal and Marino, 2015; Stoelhorst and Richerson, 2013; Van Driel et al., 2015). Within this nested hierarchy of levels, different entities, represented in a dualistic fashion through coding-effect, co-evolve over time. Two co-evolving entities, thus, mutually select variants in the other through their expression in effects, which result in the selective retention of underlying coding.

Third, at each level of the co-evolutionary process, evolution occurs through the mechanisms of *variation, selection* (through feedback) *and retention* (Murmann, 2013; Volberda et al., 2014). In this manner, a variation occurs in entity A's coding, which results in a change in the corresponding effect. There is then a *selection of* this varied effect, if the fit with entity B (i.e., the other party in the co-evolutionary relationship) is more favorable. This corresponds to a *selection for* the underlying coding in A, as information is retained for future evolutionary cycles of variation-selection-retention. Each entity, thus, evolves over time through the *variation* of the coding, the subsequent feedback-based *selection* of the corresponding effect, and resultant *retention* of the underlying coding.

Finally *fourth*, the relationship between co-evolving entities needs to be *specific, reciprocal* and *simultaneous* (Janzen, 1980). Co-evolutionary relationships are agnostic with regard to the directionality of causation, as both upward and downward causation are possible and concurrent (Nuismer, 2017).

To illustrate these distinctive features at multiple levels of analysis, a simple co-evolutionary account can be presented. In this regard the service operation of a fast food chain is examined, where food preparation processes co-evolve alongside the changing tastes of customers.

Individual Level: When completing a task, such as the preparation of a sandwich, individual employees will predominantly enact the collective routine associated with that task. Assuming a practice-based approach (see above), this food preparation routine is, therefore, represented by a dualism of ostensive understanding (coding) and enacted performances (effect), as shown in Figure 1. Over time, the employee may vary this routine, for instance by adding extra sauce or changing key ingredients (see Figure 1-a). If that employee believes these changes might receive favorable feedback from the customer, (s)he will select this variation in coding, enact the change and make the new sandwich (see Figure 1-b). Feedback is then received from the

customer and, following interpretation of this by the employee, there is a *selection of* variant performances (i.e., effect), and a *selection for* associated underlying ostensive understandings (i.e., coding), which become retained over time (see Figure 1-c).

[INSERT FIGURE 1 ABOUT HERE]

This evolution of food prep routines is *specifically* linked to an evolution of customer beliefs. The customer hold beliefs about what a sandwich should, for instance, include or taste like. Over time, a customer may change her/his beliefs, for example, believing that avocados should be included (see Figure 1-d). This, in turn, creates an expectation on the customer's part that is either confirmed or denied through the experience of eating the sandwich (see Figure 1-e). If the experience is favorable, there will be a *selection of* the sandwich (i.e., effect) and a *selection for* the associated belief (i.e., coding) (see Figure 1-f).

The customer can inform the employee about a preferred change in ingredients for example, who, in turn, may change their understanding of the food preparation routine. A change in the customer's belief might, therefore, trigger a change in how the employee prepares that sandwich, through the responses and feedback given following the enactment of the associated food prep routine. Likewise, a change in the employee's routines might lead to a change in the customer's belief, through the expectations and experiences of eating the sandwich (see Figure 1). This co-evolutionary interaction is, thus, both *reciprocal* and *simultaneous* as outlined in the fourth principle above. Furthermore, this co-evolution can occur not only between employee and customer at the level of the individual but also between different levels.

Group Level: The food preparation routine may also change within the local group of employees. Again, individuals are capable of attempting to vary ostensive understandings (coding) that

might result in the *selection of* resultant effects. However, now the enactment and feedback from other colleagues is played out within the selection mechanism of the group of employees (Breslin, 2011; 2014) (see Figure 1-g). Similarly, the beliefs held by the customer are shaped by the choices made and beliefs held by others within their peer group (see Figure 1-h). Through communication, dialogue and negotiation (Brown and Duguid, 1991; Lave and Wenger, 1991), individual selection mechanisms become reconciled within the collective selection mechanism (see Figure 1-g, h), resulting in a set of shared actions within the group of employees or customers, respectively. The routine represents multiple levels of analysis through the coding-effect dualism, as outlined in the first two principles above.

Each individual employee or customer will interpret feedback both from other individuals and the world outside the group, including the wider organization and community (see Figure 1-i, j) (Daft and Weick, 1984; March and Olsen, 1975). In this way, whilst one individual employee might interpret feedback based on the use of the collective food preparation routine as positive, another individual might interpret this differently and call for a modification in the routine (Breslin, 2011; 2014). Over time different interpretations are resolved within the group through dialogue, negotiation and socialization (Lave and Wenger, 1991) as routines are retained. In this manner, changes in the employee or peer group's coding can result in a *simultaneous* and *reciprocal* change in either the employee's or the customer's coding (see Figure 1). The mechanisms of VSR, thus, define the process of change at each level, as outlined in the third principle above.

Organizational Level: At a higher level, the evolutionary processes of each group of employees are played out within the context of the fast food chain. The organization will, thus, be a polythetic collection of local and organizational routines (see Figure 1). Evolving entities at each level are discrete in the sense that selection occurs at both levels, depending on the differential

degree of fitness. Therefore, whilst different groups within the organization develop routines in the completion of activities, such as *food preparation, food storage* and *product development*, they also "share" broader organizational routines associated, for instance, with the management of information through the company's information system. These organizational routines are typically learned during the employee's training and induction period, and are shared with other members of the food preparation group (see Figure 1-i).

Individuals and groups can attempt to persuade others within the company to vary these organizational routines, perhaps by presenting alternative approaches to, for instance, product development (see Figure 1-i). Individuals and groups can also choose to select the organizational routine, or may even choose to select alternative group-level routines associated with product development. Again, these decisions to retain group or organizational routines will depend upon the feedback from other groups, managers and agents external to the organization, such as customers. Ultimately the needs and tastes of these parties may also change over time, with individuals, groups and the wider organization co-evolving to suit.

The beliefs of an individual customer will be influenced and shaped by wider beliefs within the community, for instance, through social media (see Figure 1-j). The organization, in turn, might attempt to shape these community-level beliefs through marketing campaigns (see Figure 1-k). The organization might also seek to better understand changing beliefs within the community through market research (see Figure 1-l). At this organizational/community level, there is, therefore, a further co-evolutionary relationship between the organization and customer, which is *specific*, *simultaneous* and *reciprocal*. Thus, an organization might learn about a change in consumer tastes through market research which, in turn, results in a change in the associated food prep routine. It then markets this change to the consumers, who, in turn, change their beliefs about sandwiches consumed at that fast food chain.

4.2. What makes co-evolution distinctive?

As explained in our analysis, many accounts of co-evolution given in MOS do not seemingly adhere to these four principles. Thus, we argue that the inconsistency in addressing each of these results in a lack of theoretical precision and coherence in resultant conceptualizations of the co-evolutionary process. Of course, the co-evolutionary approach does share features with other movements in MOS, such as micro-foundations and dynamic capabilities; however, key differences also exist, which limit the potential for the latter approaches to fill this scholarly void.

The central premise of the micro-foundations movement, for example, is that a phenomenon at a particular level can be explained through the actions and interactions of phenomena or actors at a lower level (Felin et al., 2015). In this sense, they present a *multi-level approach* and a causal chain of events, whereby social outcomes are aggregated from individual actions, which, in turn, have their own individual-level causes. Thus, collective constructs, such as routines and capabilities, emerge and are aggregated from the actions and interactions of constituent components, such as individuals, processes, and structure (Felin et al., 2012). In this sense, we have a *specific* relationship between entities that change at two different levels of analysis, which may lead to co-evolution. Thus, the collective food preparation routines, in our example given above, can be influenced by individuals experimenting with new food preparation habits.

However, whilst micro-foundations scholars do not deny the possibility of downward causation (i.e., group routines influencing individual habits), their focus is on upward chains of causation, as outcomes are seen to occur at a higher level (Felin et al., 2015). As such, they imply an upward directionality to causation, compromising the co-evolutionary principle of *reciprocity*. From an evolutionary perspective, causation does not have a directional preference. As Winter (2011) notes "everything has causal antecedents, and causal antecedents are, in a broad sense, evolutionary antecedents".

Dynamic capabilities also represent an approach that includes *multiple levels of analysis*. In this way, they are decomposed into a hierarchy of lower level skills, processes, procedures, organizational structures, decision rules, and disciplines that assist in sensing, seizing and transforming organizations (Teece, 2007; Teece et al., 2000). Dynamic capabilities involve adapting, integrating and reconfiguring skills, resources and competencies from many parts and levels of the organization to match changes in an external environment (Teece et al., 2000). As they adapt to changes in an external world, by reconfiguring and integrating multiple elements from within the organization, there is a *specific* and *reciprocal* relationship between external and internal change. Moreover, as the adaptation process is time-pressured and rapid (Teece et al., 2000), this connection between the organization and environment can be *simultaneous*. In this sense, dynamic capabilities meet two of the co-evolutionary principles outlined above.

However, for both micro-foundations and dynamic capabilities, the principle that entities at each level have a *dualistic* representation does not hold. With micro-foundations, a causal dualism is presented between a phenomenon at one level (e.g., actors, processes and structure) and its "outcome" at a higher level, with the two levels connected through an aggregation process (Felin et al., 2012; 2015). Felin et al. (2012) propose choices and agency, characteristics, abilities, or cognition, as individual-level components. How would each of these evolve over time? How, for instance, would cognition be selected if the selecting entity does not have direct access to that tacit cognition? How would agency by retained through repeated evolutionary cycles? What does the inherited property of agency look like? Equally, Teece et al. (2000) differentiate between factors of production, resources, routines, core competences, and dynamic capabilities; however, they do not identify coding and effect elements for any of these. For example, in what way does the routine (that they refer to) reflect ostensive understandings of those enacting them (i.e., coding), or performative sets of actions created through their enactment (i.e., effect)? To develop an evolutionary account through the mechanisms of *variation-*

selection-retention, each of these phenomena should be represented by a dualism of coding and effect. Otherwise, it is unclear what is varied, how the mechanisms of variation, selection and retention occur through each evolutionary cycle.

4.3. Conclusion

It appears clear that all our resulting evidence (and the subsequent questions raised above) leave a large space for research and improvement, especially if, in the near future, both scholars and practitioners aim at building a convergent theoretical and methodological "language" (and a deriving body of knowledge) in this expanding meta-theoretical perspective in MOS (Andriani and Carignani, 2014; Dollimore and Gomes, 2014; Dopfer and Potts, 2007; Hekkert et al., 2007). We are conscious that, from a strictly *procedural* point of view, from the beginning we have conjectured this contribution as a conceptual start, hopefully soliciting further discussion and even more specific analyses; in other words, we acknowledge that, at this stage, we have deliberately avoided a strict systematic review protocol, while preferring to focus on the literature with which, given our research background and profile, we are more confident.

However, although aware of the limitations above, we believe that, from our article, some valuable evidence has already emerged: on the one hand, it seems to us that "co-evolution" has become, at least, a *suggestive* term to use in journal articles increasingly published in major MOS outlets; but, on the other hand, it also seems to us that the majority of the current investigations often use this term without substantive explanation or, at least, with the assumption that readers are aware of some general understanding of it. In other words, it appears that most of these investigations in management and organization theory ultimately fail in theoretically addressing why and how co-evolutionary processes between and among units of analysis eventually take place.

"From so simple a beginning endless forms most beautiful and most wonderful have been, and are being, evolved" (Darwin, 1859: 490). In the closing lines of the *Origin of the Species*, Darwin himself wonders at the forces driving evolution in natural sciences, while at the same time putting forward the thought-provoking possibility that evolutionary forces might also be at work in other domains of study. In this regard, we believe that a well-refined MOS theory of co-evolution can help both scholars and practitioners to (almost) safely conceptually navigate the troubled waters of the current macro-economic *sea*. At the same time, we also believe that conceptual precision and consistency across studies are key to advancing knowledge in this area, and this is why we do hope that our article has somehow contributed to this aim.

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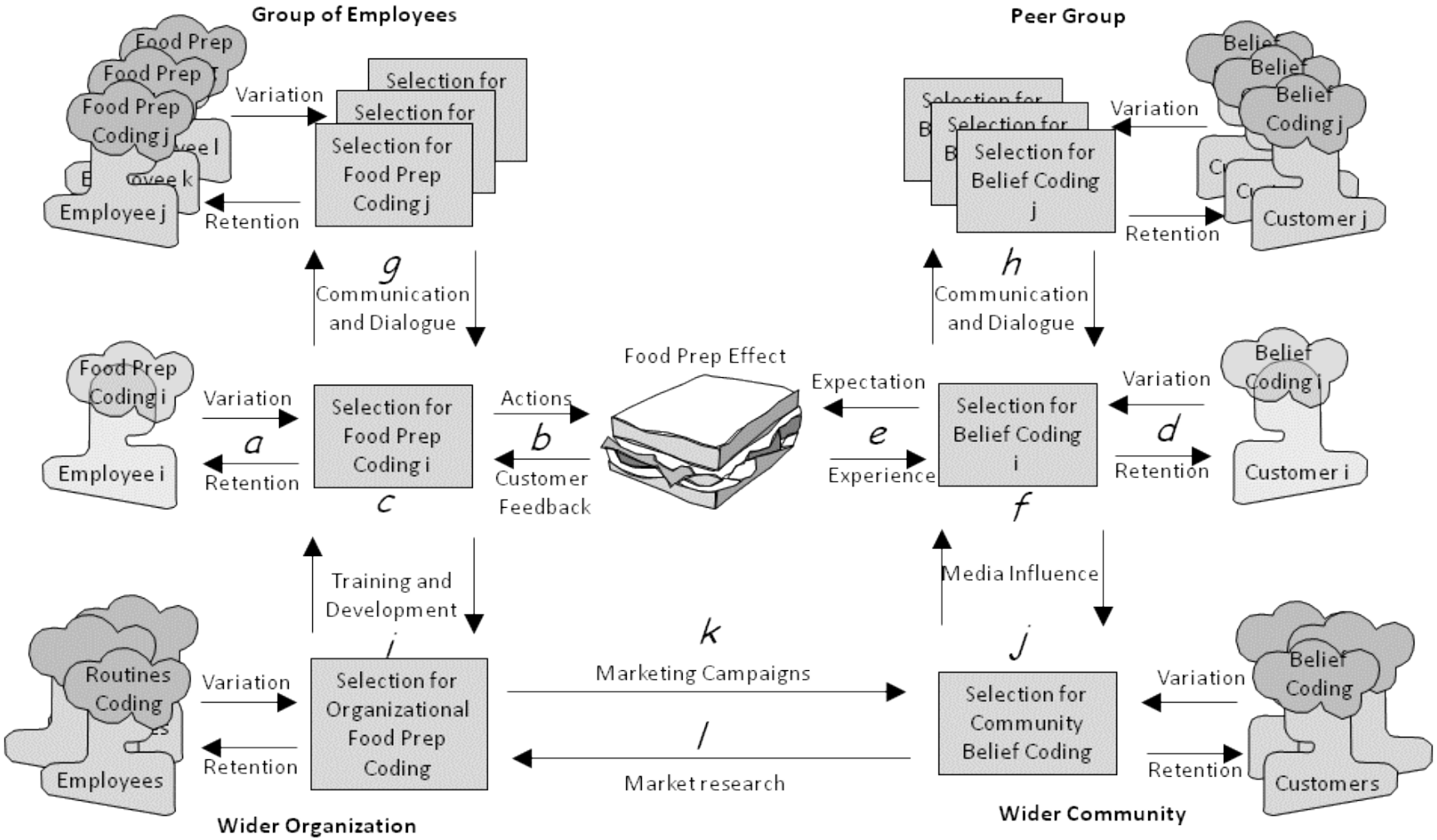
Figure 1. Illustrative example of the co-evolution of routines and beliefs in a fast food chain.



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Volume 155, June 2020, https://doi.org/10.1016/j.techfore.2020.119964

Table 1. Some representative co-evolutionary accounts in the new century (in increasing chronological order).

Year	(First) Author	Methodology	Journal Area (ABS 2018)	Units of Analysis	Causal Relationships (1 or 2-way effect)	Processes	Years Observed	Industry
2000	Fleck	Conceptual	Innovation (Book Chapter)	Artifact	2-way (Artifact, activity)	-	-	-
2001	Flier	Qualitative (1 industry)	Strategy	Technological/ regulatory environment, firms' strategic renewal	1-way (Country system, industry, firms)	-	9 (1990-1999)	Financial Services (Europe)
2001	Huygens	Qualitative (6 firms)	Organization Studies	Industrial dynamics, firms' capabilities	2-way (Country system, industry, firms)	-	100 (1877-1977)	Music (UK)
2001	Jenkins	Qualitative (1 industry)	Organization Studies	Transparency of component technology, technologically dominant designs	2-way (Industry, firms, technological components)	Self-reinforcing (power, momentum, uncertainty resolution)	15 (1967-1982)	Formula One
2001	Jones	Mixed	Organization Studies	Institutional environment, industrial dynamics, firm/entrepreneurial capabilities	2-way (Country system, industry, firms, entrepreneurs)	Institutional theory, resource based view	35 (1985-1920)	Movie
2001	Lewin	Conceptual	Organization Studies	Institutional environment, industrial dynamics, firms' capabilities	2-way (Country system, industry, firms)	-	-	-

2001	Rindova	Qualitative (2 firms)	General Management	Organizational form/function	2-way (Industry, firms)	Strategic trust (dynamic capabilities/intentions) re-examines form/function of firms, which colors industry-level competition	4 (1994-1998)	Internet
2001	Volberda	Qualitative (8 firms)	Strategy	Institutional environment, industrial dynamics, firms' strategic renewal	2-way (Country systems, industry, firms)	Context (external/internal), content (exploration/ exploitation), process (speed)	7 (1990-1997)	Financial Services (Holland, UK)
2002	Burgelman	Qualitative (1 firm)	General Management	Industrial dynamics, firms' capabilities, CEOs' strategic intent (strategic inertia)	2-way (Industry, firms)	Multi-level grounded theorizing	11 (1987-1998)	PCs (US)
2002	Carney	Qualitative (1 business model)	Organization Studies	Institutional environment, family firms' business models	2-way (Country system, family firms)	Path dependence	55 (1945-2000)	Family business groups (Southeast Asia)
2002	Geels	Qualitative (1 industry)	Innovation	Technology, user preferences, markets	2-way (Sociotechnical landscapes, regimes, users)	VSR (Adaptation/ cascade dynamics)	120 (1780-1900)	Shipbuilding
2002	Zollo	Conceptual	Organization studies	Dynamic capabilities, operating routines	2-way (Firms, external stimuli/feedback)	VSR (Accumulation, articulation and codification mechanisms)	-	-

2003	Flier	Qualitative (13 firms)	General Management	Institutional environment, industrial dynamics, firms' strategic renewal	2-way (Country systems, industry, firms)	Context (external/internal), content (exploration/ exploitation), process (speed)	7 (1990-1997)	Financial Services (Holland, UK, France)
2003	Rodrigues	Qualitative (1 firm)	General Management	Organizational values, norms, rules	2-way (Industry, firm)	Environmental change, internal organizational development	27 (1973-2000)	Telecommunications (Brazil)
2003	Volberda	Conceptual	General Management	-	2-way (Institutions, industry, firms)	Multidirectional causalities (micro/macro co-evolution)	-	-
2004	Dopfer	Conceptual	Economics	Micro, meso, macro rules	2-way (Economic structures)	Meso trajectories (Origination, adoption, retention)	-	-
2004	Henderson	Quantitative	General Management	External/internal selection of products	2-way (Industry, firms)	VSR	19 (1975-1994)	PCs
2004	MacPherson	Conceptual	Innovation	Dynamic capabilities	2-way (Experience accumulation, knowledge articulation/ codification)	Generation/ adaptation of operating routines	-	-

2004	Ruef	Quantitative	Social sciences	Organizational populations	2-way (School forms)	Population ecology /density-depend-ence	234 (1765-1999)	Medical schools (US)
2005	Jacobides	Conceptual (2 examples)	Strategy	Transaction costs, firms' capabilities	2-way (Industry, firms)	VSR	8 (1981-1989)	Mortgage banking (US)
							12 (1980-1992)	Watches (Switzerland)
2005	Wilkinson	Conceptual	Marketing	Systemic properties	2-way (Firm, environment)	Self-organization; participatory planning/adaptation	-	-
2007	Djelic	Qualitative (2 industries)	Social Sciences	Institutions	2-way (Transnational systems)	Multi-level (de)-in-stitutionalization	45 (1945-1990s)	Various
2007	Eyuboglu	Conceptual	Marketing	Governance patterns	2-way (Related firms, business partners)	Evolutionary Selection	-	-
2007	Macpherson	Conceptual	Innovation	Entrepreneurial capabilities	2-way (Experience)	-	-	-
2008	Laaksonen	Qualitative (1 industry)	Marketing	Relationships (interfirm trust, interdependence)	2-way (B2B custom-ers/suppliers)	Power dependency, TCA (behavior changes)	-	Paper (Finland)
2008	Malerba	Conceptual (Simulation modelling)	Social sciences	Industry texture (integration, specialization, firm boundaries)	1-way (Related industries, firms)	Accumulation of capabilities, learning, market competition (selection)	-	Comput-ers/Semicon-ductors
2008	Noailly	Conceptual (Simulation modelling)	Economics	Pesticide use/re-sistant genes in pest populations	2-way (Economic/ ecological system)	VSR (gene-centric version)	-	Agriculture
2008	Pajunen	Qualitative (1 firm)	General Management	Activities, resources/ capabilities	2-way (Industry, firms)	VSR	31 (1974-2005)	Microbiology (Finland)

2009	Arthur	Conceptual	Innovation (Book)	Science, technology	2-way (Multiple participants)	Symbiotic relationship	-	-
2009	Quinn	Qualitative (2 food value chains)	Marketing	Business forms, technology, institutions, strategies (industry architecture)	2-way between organizations; 1-way from context to businesses (Value-chain members)	Competition/cooperation; symbiosis/commensalism (community/population ecology)	73 (1932-2005)	Grocery (UK, Ireland)
2009	Shepherd	Conceptual	Economics	Memes	2-way (Participants in memes)	VSR	-	-
2010	Cordes	Conceptual	Economics	Cultures	2-way (Business environments)	-	-	-
2010	Hodgson	Conceptual	Economics	Environment, organizations	2-way (Environment, complex population systems)	VSR (replicators, interactors)	-	-
2010	Pacheco	Conceptual	General Management	Entrepreneur	2-way (Entrepreneur, social/economic environment, opportunity/market conditions, strategies, outcomes)	-	-	-
2010	Waring	Conceptual	Economics	Behaviors, beliefs, institutions, human genes, other species, physical environment	2-way (Humans, other species, institutions)	VSR	-	-
2011	Breslin	Conceptual	Social Sciences	Habits, routines, cognitive frameworks	2-way (Individuals and groups within organizations)	VSR (replicators and interactors)	-	-

2011	Boschma	Conceptual	Social Sciences	Science, technology	2-way (Multiple participants)	Symbiotic relationship	-	-
2011	Dantas	Qualitative (1 firm)	Social Sciences	Knowledge innovation networks, firms' capabilities	2-way (14 networks of technology/ capabilities)	Self-reinforcing	40 (1960s-2000s)	Oil & Gas (Brazil)
2011	Ford	Conceptual	Marketing	Activities, roles, re-sources in networks	2-way (Actors in a business network)	Actors' shared problem-coping	-	-
2011	Foxon	Conceptual	Economics	Joint structures (sociotechnical regimes, techno-institutional complexes)	2-way	System thinking	-	Low Carbon Economy
2011	Koza	Qualitative (1 firm)	Strategy	Decisions in strategic (international) assembly	2-way (Multinational holding, local subsidiary)	-	50 (1960s-2010)	Automotive (Turkey)
2011	Lewin	Conceptual	International Business	Offshoring decisions in global sourcing	2-way (Institutional environment, industry, firm factors)	Multi-levelness	-	-
2011	Rerup	Qualitative (1 firm)	General Management	Routines	2-way (Schema)	Trial/error learning	7 (2001-2008)	Research/ Education (Denmark)
2012	Abatecola	Conceptual	Social Sciences	TMT misperceptions, corporate crises	2-way (Environment, corporate TMT mistakes)	Decisional heuristics, traps	-	-

2012	Child	Qualitative (1 firm)	General Management	Environment, firm	2-way (Institutions, industry, firms)	Political perspective (power, reciprocal influence)	16 (1993-2009)	Container terminals (China)
2013	Alvarez	Conceptual	Organization Studies	Business opportunities, meanings, beliefs, opinions, understandings	2-way (Venture creation process)	-	-	-
2013	Johansson	Conceptual	Marketing	Routines, capabilities	2-way (Business relationships, firms)	VSR	-	-
2013	Murmann	Qualitative (1 industry)	Organization Studies	Industry	2-way (Industry, academic discipline)	VSR	64 (1850-1914)	Synthetic Dye (UK, Germany, France, Switzerland, US)
2013	Najak	Qualitative (1 industry)	Business History	Institutions, practices, discourses, cultural norms	2-way (Entrepreneurial groups)	Entrepreneurial field (discourse/ institutional theory)	86 (1923-2009)	Telecommunications (India)
2013	Stoelhorst	Conceptual	Economics	Human genes, cultures (cooperation/rivalry)	2-way (Human groups within/between organizations)	Naturalistic theory	-	-
2014	Andriani	Conceptual (with examples)	Innovation	Technological exaptation, modularization	2-way (Modular forms, functions)	Multilevel circular feedback	-	-

2014	Abatecola	Conceptual	General Management	TMT heuristics	2-way (Environment, TMT socio-demographic features/personality, circular feedback)	Self-reinforcing	-	-
2014	Breslin	Conceptual (Simulation modelling)	Social Sciences	Routines (exploration/ exploitation)	2-way (Agents at multiple organizational levels)	VSR	-	-
2014	Clarke	Conceptual	Entrepreneurship	Entrepreneurial firm	2-way (Suppliers, markets, employees, local/international communities, natural environments, competitors)	Collaborative systemic relations	-	-
2014	Volberda	Conceptual	Organization Studies	Management innovation	2-way (Organizational, inter-organizational, and macro level)	VSR	-	-
2015	Grodal	Conceptual	General Management	Technological designs, categories	2-way (Industry emergence)	Design/categorical echoing and discerning	-	-
2015	Levinthal	Conceptual (Simulation modelling)	Organization Studies	Routines	2-way (Intra-organizational learning)	Variation, Selection, Plasticity	-	-

2015	Simsek	Conceptual	General Management	Imprints	2-way (Individual, group, organiza-tion, industry)	Genesis, metamor-phosis	-	-
2015	Spisak	Conceptual	General Management	Biological/cultural evolution (organizational leadership)	2-way (Individuals, groups)	Niche construction	-	-
2015	Van Driel	Qualitative (1 firm)	Business History	(Extra)-institutional environment, industrial dynamics, firms (longevity)	2-way (Environment, firm)	Exploration, ex-ploitation	182 (1818-2000)	Warehousing (Holland)
2015	Venaik	Quantitative	Marketing	Cultures, institu-tions, economies	1-way (National systems)	Cultural similari-ties (globalization)	-	Various
2016	Argote	Conceptual	Organization Studies	Transactive Memory Systems (TMSs)	2-way (Participants in TMSs)	-	-	-
2016	Breslin	Conceptual	General Management	Routines (entity/practice)	2-way (Individual, group and organizational level)	VSR (replicators and interactors)	-	-
2016	Cafferata	Conceptual	General Management	Country system, industry, firms	2-way (Environment and business systems)	System thinking, dialectical ap-proach	-	-
2016	Dong	Qualitative (1 firm)	International business	Environment, form/ function (of firm)	1-way (Firm, environment)	Fit/adaptation	22 (1990-2012)	Sporting goods (China)
2017a	Almudi	Conceptual (Simulation modelling)	Economics	Utopias/ideas (market, State, civil liberty, group	2-way (Utopias,	Replicator, feedbacks	50 (Since 1960s)	US society

				identity, nature/environment)	socio-institutional change)			
2017b	Almudi	Conceptual (Simulation modelling)	Economics	Utopias/ideas (market, State, environment)	2-way (Utopias, sustain-ability transitions)	Replicator, feedback	40 (Since 1980s)	Western societies
2017	Aluko	Qualitative (1 firm)	Business History	Institutional environment, firm	2-way (Firm, environment)	Fit (power positions, alignment with norms)	122 (1869-1991)	Supermarket (UK)
2017	Olsen	Qualitative (1 industry)	Organization studies	Institutional structures, group formation agency	2-way (State, individuals)	Isolation, co-optation	49 (1951-2000, Mexico); 27 (1973-2000, Brazil)	Microfinance (Mexico and Brazil)
2017	Ozuem	Qualitative (1 industry)	Marketing	Shopping preferences, purchasing formats	2-way (Retailers, consumers)	Adoption	-	Video games
2017	Paniccia	Qualitative (14 firms)	Sector Studies	Territories, innovations, tourist firms' capabilities	2-way (Territories, tour-ist firms, tourists)	Evolutionary economic geography	2 (2014-2015)	Tourism
2017	Sargis-Roussel	Conceptual	General Management	Routines	2-way (Social capital reciprocal interaction)	VSR (ostensive/ performative aspects of routines)	-	-
2017	Weber	Conceptual	Organization studies	Interfirm governance (trust, learning, control)	2-way (Firms)	Cognition, attribution	-	-
2018	Almudi	Conceptual	Economics	Complex population systems (personal realm, market, State)	2-way (Individuals, Firms, Civil organizations)	VSR (promotion mechanisms in contemporary capitalism)	-	-
2018a	Uli	Qualitative (1 firm)	Operations and Technology	Performance appraisal routines, learning mechanisms	2-way (Individuals, groups)	VSR	1 (2014)	Service

2018b	Uli	Qualitative (1 industry)	Organization Studies	Industrial dynamics, technological innovations, firms' capabilities	2-way (Industry, firms)	Dialecticity (dynamic adaptation matrix)	14 (1999-2013)	Music

Table 2 What is Co-Evolving?

Levels/Entity Types	A. Coding	B. Effect	C. Ambiguity (unclear whether it is a coding or an effect)	D. Variables (neither coding nor effect)
Community	National institutions (Djelic and Quack, 2007)	Regulatory environment structures (Flier et al., 2001)	Institutional environment (Van Driel et al., 2015) Science (Arthur, 2009)	
Industry/Market	Sociotechnical regimes (Foxon, 2011)	Technological designs (Grodal et al., 2015) Industry architecture (Quinn and Murray, 2009); Industry culture (Cordes et al., 2010)	Industry technology (Boschma and Frenken, 2011)	Industrial dynamics (Uli, 2018b) Transparency of technology (Jenkins and Floyd, 2001)
Inter-organizational (*)	Inter-organizational routines and capabilities (Koza et al., 2011)	Activities and roles in networks (Ford, 2011) Interfirm governance (Weber, 2017)	Knowledge networks (Dantas and Bell, 2011)	
Organizational	Organizational routines and capabilities (Paniccia and Leoni, 2017)	Conducts of firms in relations (Eyuboglu and Buja, 2007) Organizational form and function (Quinn and Murray, 2009) Firm's innovations (Uli, 2018b) Managerial decisions (Lewin and Volberda, 2011)	Organizations' resources (Pajunen and Maunula, 2008)	Organizations' competitive advantages (Rindova and Kotha, 2001)
Intra-organizational (**)	Group routines (Levinthal and Marino, 2015)	Group expressions and structures (Levinthal and Marino, 2015)		
Individual	Entrepreneurial capabilities (Macpherson and Holt, 2007) Human genes (Stoelhorst and Richerson, 2013) Customers' preferences (Ozuem et al., 2017)	Humans' behaviors and beliefs (Waring, 2010)	Entrepreneurs (Pacheco et al., 2010)	

* E.g., in networks and interfirm relations.
** E.g., groups within an organization.