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Accelerating the innovation process – a systematic review and realist synthesis of the research literature

Dr Paul Ellwood*
Senior Lecturer in Management,
University of Liverpool Management School, Chatham Street, Liverpool, L69 7ZH,
0151 795 3726,
Paul.ellwood@liverpool.ac.uk

Dr Paul Grimshaw
Research Associate
Leeds University Business School, Maurice Keyworth Building, University of Leeds, Leeds, LS2 9JT,
0113 243 1751
p.grimshaw@leeds.ac.uk

Prof. Krsto Pandza
Professor of Strategy and Innovation
Leeds University Business School, Maurice Keyworth Building, University of Leeds, Leeds, LS2 9JT,
0113 343 4509,
k.pandza@leeds.ac.uk

Abstract

There is a continued interest amongst academics, practitioners and policy makers in methods to achieve accelerated innovation. Academic studies of this complex phenomenon have succeeded in reaching a high degree of consensus on the antecedents of innovation speed. Our aim in this review is to further elucidate the mechanisms underlying management interventions to promote speed. The review adopts a theory-led, realist synthesis of innovation speed research – the first example of this methodology in management studies. We develop a new time-based framework for categorizing the innovation speed literature. The framework has a CIMO-logic, and is built by invoking the organisational studies literature on time.

We contextualise the innovation speed literature in relation the three generic temporal challenges faced by all organisations: reducing temporal uncertainty; resolving temporal conflicts over activities; and allocating resources amidst conditions of temporal scarcity. We problematize extant explanations of innovation speed as not taking account of different temporal orientations (temporal dichotomies) within innovation work, and thereby neglecting a potential barrier to achieving accelerated innovation outcomes. We further draw upon the literature on time in organisations to suggest new avenues of research, and methodological approaches new to the study of innovation speed. The principal contribution of this review is to offer a new conceptual perspective on the complex empirical research examining how innovation projects may be accelerated from original idea to launch.

Keywords: Innovation speed, Accelerating innovation; temporal dichotomies; systematic review; realist synthesis; CIMO-logic; New Product Development (NPD).

Introduction

This paper presents a systematic review of research that has sought to identify how innovation projects may be progressed more quickly from first idea to launch. Studies of accelerated innovation have proved popular with academic researchers, professional innovation managers and policy-makers. This topic emerged as an area of significant research interest in the late 1980's and early 1990's with the burgeoning focus on globalization and the increasing pressure of time based competition (Stalk, 1988; Starr, 1992). The subject remains a feature of contemporary business discourse on globalization and competitive strategy (e.g. Williamson and Yin, 2014), as increased innovation speed has been shown to be associated with new product success as measured financially, or in terms of technical quality and customer value (Cankurtaran et al., 2013). However, some authors have argued that an over-emphasis on speed in innovation strategies can have negative trade-offs (Calantone and Di Benedetto, 2000), hidden costs (Crawford, 1992) or risks fixating management attention to the detriment of other factors (Lambert and Slater, 1999; Chen et al., 2012; Kessler and Bierly, 2002; Smith, 1999).

The challenge of innovation speed has been framed in a number of ways: reducing new product development cycle times (Griffin, 1993; 1997) and conversely increasing rates of product obsolescence; delivery of innovative products to market quickly (Jones, 2003) and the benefits of strategies such as 'first-mover' to provide 'lock-in' advantages (Lieberman and Montgomery, 1988; Dumaine, 1989); or fast responding, cost saving, 'second-to-market' strategies (Emmanuelides, 1991). Empirical research has sought to identify the antecedents of innovation speed predominantly in the context of new product development. Such studies have generated a long list of

acceleration techniques that are suggested may speed an idea to launch. The resulting literature spans a range of industries, firm sizes, technologies and geography. In undertaking this review we sought an explanation of the mechanism of speed amidst such a diversity of innovation projects. We followed a systematic review process (Denyer and Tranfield, 2009) in order to: provide a transparent account of our method; be able to include relevant data regardless of the types of research design used in original papers; and be able to develop explanations for how different acceleration techniques actually worked. The overarching question that motivates this literature review is: what management interventions have been employed to accelerate innovation projects and reduce the time taken to progress from 'idea' to 'launch'?

Existing literature reviews on this subject, although very informative in identifying numerous antecedents and contingencies, are limited in articulating underlying mechanisms that explain how interventions increase innovation speed. In response we propose a new framing of innovation speed by examining the way in which time (rather than explicitly speed) has been studied within organisations. We argue that speeding innovations requires both the efficient and effective use of time. This in turn requires a richer perspective on the way time is experienced in organisations (Bluehorn and Denhardt, 1988; Clark, 1985) than has been evident in the existing literature reviews of innovation speed. We invoke such ideas about how time is experienced in order to build a framework to guide or systematic review based on a "CIMO" architecture (Denyer and Tranfield, 2009). The findings concerning management interventions for speed are then presented in terms of temporal categories (rather than more conventional categories such as technology, sector or firm size). By these means we identify a barrier to innovation speed that has not been

hitherto developed within this literature: a slowing of innovation work as a result of different temporal orientations (or temporal dichotomies) being held by innovation actors. The discussion section examines the implications of the findings for our conceptual understanding of the mechanisms by which speed is realised in innovation work. We conclude by identifying areas for future academic research and implications of our ideas for innovation practitioners. Our motivation in this whole endeavor is to extend the terms on which innovation speed is understood and researched.

Previous Literature Reviews of Innovation Speed

There have been a number of literature reviews examining the concept and practices of innovation speed (Zirger and Hartley, 1994; Brown and Eisenhardt, 1995; Kessler and Chakrabarti, 1996; Chen et al., 2010; Cankurtaran et al., 2013). A sixth literature review (Menon et al., 2002) is not as well developed as the others, uncovers no additional insights and fails to reference any of the earlier reviews, and is therefore not examined here in any detail. The contribution of each of the five major reviews is examined briefly in this section.

The "acceleration techniques" (Zirger and Hartley, 1994), organisational "factors" (Brown and Eisenhardt, 1995; Kessler and Chakrabarti, 1996) and "antecedents" (Chen et al., 2010) from previous reviews are summarised in Table 1. They are further categorised using labels similar to those that are used in the reviews themselves: "Strategy"; "Project"; "Team/people"; and "Process". The Table illustrates a similarity in thinking and approach evident in the existing reviews. We argue that this thinking is limited in a number of ways. Firstly, we note the

dominance of an approach taken toward innovation speed that is akin to that of efficient project management techniques. The innovation journey between original idea to launch of product is conceptualised as entailing the execution of a series of tasks. Faster innovation journey times are then achieved by a judicious combination of: a) shrinking the time taken to complete a task; b) running tasks concurrently; c) avoiding waiting time between tasks and d) avoiding the repetition of tasks. From this perspective innovation projects are treated as being no different from any other project. Indeed Kessler and Chakrabarti acknowledge that their propositions advocate a similar approach to that when improving the efficiency of manufacturing processes (Kessler and Chakrabarti, 1996: 1181). Time within innovation projects thus becomes a simple resource, and the achievement of accelerated innovation becomes a matter of using that resource efficiently. Our contention is that the complexity inherent to the organisation of innovation projects (Phillips, 2014; Crossan and Apaydin, 2010) makes this project management orientation in extant reviews conceptually limited. Innovation projects cannot simply be compared to well-defined manufacturing process where the detail of each individual task is known in advance. The wider innovation literature has acknowledged that innovation processes are complex (Dougherty and Dunne, 2011; Andriani and Carignani, 2014) and non-linear (Van de Ven et al., 1999; Meyer et al., 2005), and it is therefore intriguing that when speed of such processes is concerned scholars very often assume that effective time and project management techniques are sufficient solutions. Our response in this paper is to introduce a wider range of perspectives on time in relation to debates about innovation speed.

Secondly, many of the techniques/factors/antecedents listed in Table 1 are not, of themselves uniquely concerned with speed. For example, project leadership might manifest itself in a number of ways completely unconnected with speed (e.g. in relation to project cost or quality). Indeed, taken out of context then a list of factors (cf Table 1) comprising leadership, top management support, clear goals, cross-functional teams composed of experienced people, working to a well-designed process, might be important for practically any management challenge. Furthermore, these acceleration techniques do not, of themselves, explain the response to changes in speed-related priorities during the course of projects. The issue for any conceptual model of innovation speed is to explain how elements such as project leadership operate in order to generate accelerated innovation outcomes. In this paper we seek to elucidate the mechanisms that explain how the elements listed in Table 1 succeed in engendering innovation speed. The need to explain the acceleration mechanisms was part of the aims of the review of Zirger and Hartley (1994). We extend their explanation by examining the speed-related implications of a wider range of temporal perspectives for the organisation of innovation.

The third limitation we seek to redress is the exclusion of qualitative studies in the most extensive reviews of innovation speed (Kessler and Chakrabarti, 1996; Chen et al., 2010; Cankurtaran et al., 2013). Notwithstanding the significance of the contributions of these studies to our understanding of innovation speed, their advocacy or exclusive use of quantitative research, necessarily excludes studies based upon qualitative data. The best of the latter involve rich accounts of innovation practice and offer potential insights into the way in which (otherwise) generic factors such a leadership are enacted to generate accelerated innovation.

In the next main sections we address these limitations in the existing reviews by proposing a new approach to theorisation of innovation speed in organisations: one that considers a wider range of temporal perspectives on innovation, and integrates a wider range of methodological approaches. In this we hope to build on the achievements of the extant reviews, whilst also widening the terms of scholarship on accelerated innovation. The model of innovation speed we develop is then used as a framework to guide our synthesis of the original research literature.

Table 1 – Summary of the antecedent/factors/techniques identified in extant reviews that enable accelerated innovation

Category	**Zirger and Hartley (1994)**	**Brown & Eisenhardt (1995)**	**Kessler and Chakrabarti (1996)**	**Chen et al (2010)**
Strategy	Time as goal Measure & rewards	Senior management support	Speed emphasis Goal clarity Project support, Champion presence	Emphasis on speed Goal clarity* Top management support*
Project	Part reduction, Part standardisation Incremental innovation projects		Project stream breadth Degree of change	Project complexity Project newness (technology Novelty & product newness)
Team/people	Cross-functional teams Empowered teams Co-location Dedicated team members Vendor management	Project leader with power & vision Moderate tenure Cross-functional team, Team communication processes Gatekeepers Suppliers involvement	Leader strength Member experience Team representativeness Team empowerment External sourcing	Team leadership* Team experience* Internal integration*, Functional diversity, Team empowerment* Team co-location Team dedication* External integration*
Process	Concurrent development Freezing design Use of CAD/CAM systems	Planning & overlapping Iteration & frequent testing	Project integration Process organisation	Process concurrency* Process formalisation* Iteration* Learning*

*Antecedents found by Chen et al.'s meta-analysis to be significant ($p<.05$)

Towards a New Conceptual Model of Innovation Speed

The review approach taken in this paper is that proposed by Denyer and Tranfield (2009) in their adaptation for management studies of the principles of systematic review that pertain for evidence-based medicine. Specifically we adopt a theory-led approach to the review method that draws on the ideas of realist evaluation associated with Ray Pawson (e.g., 2006; 2013). In developing a realist method of evidence evaluation (e.g. in the production of a systematic review), Pawson argues that "to infer a causal outcome between two events one needs to understand the underlying mechanism that connects them to a context" (Pawson et al., 2005: 21). He developed these ideas in relation to evaluating the effectiveness of programmes entailing interventions designed to improve some aspect of health. The approach involves articulating a theory that is inherent to the programme's design that relates the interventions made to the desired health outcomes. Evidence is then sought (e.g. from published research papers) that clarifies and refines the theory (Pawson, 2002). This method is not simply a matter of identifying "what works?" but rather seeks to understand "what is it about this programme that works for whom and in what circumstances" (Pawson et al., 2005: 22). It has been argued that this approach is particularly suited to complex social situations in which more than one mechanism may be operating (Pawson et al., 2005; Rogers, 2008). Denyer et al. have suggested (2008) that such complexity is found in managerial and organisational studies as well as the healthcare settings with which Pawson's work is concerned.

The structure of our working theory is articulated in terms of a "CIMO logic" (Denyer et al., 2008; Pawson, 2006). This logic states that: for a generalisable class of

contexts (C), by using particular management intervention (I) it is possible to enable generative mechanism (M), to achieve outcome (O). The extant literature reviews in innovation speed have largely sought to establish the relationship between accelerated outcomes with a series of management interventions (cf. Table 1). Following Denyer and Tranfield our theory does not seek "generalization…in terms of the association between variables but in terms of the role and impact of generative mechanisms that play out in diffuse ways over time" (2009: 681). Therefore, this approach is not limited to the synthesis of quantitative data, and allows us to integrate good studies adopting a variety of methodologies.

Temporal dichotomies – different perceptions of time in organisations

Our approach to conceptualizing innovation speed starts by examining the way in which time (rather than explicitly speed) has been studied within organisations. To progress an innovation project more quickly is to complete its associated tasks with a more efficient and effective use of time. As we will elaborate in this section, different organisational actors may perceive the passage of time within organisations differently. Therefore, if innovation speed concerns the accomplishment of tasks within a shorter period of time, it becomes important to take account of different perceptions of time. In this manner we widen the terms of the innovation speed literature by drawing upon a wider literature studying time in organisations.

One major recurrent theme in writing in this area concerns the different ways in which time is understood within organisations; in particular whether it is an objective or a subjective phenomenon. Clark characterized the objective view as being time that is "independent of man" (Clark, 1990: 142) and perceived as linear. This

linearity carries a mechanical connotation that means organizing is seen as a succession of tasks that may be measured in quantitative terms. For this reason, the clock has become the dominant metaphor in this step-wise conception of time. The contrasting view sees time as subjective, and a socially constructed product of the values, customs and practices of organisational actors. In this view time is "defined by organisational members" (Clark, 1985: 36), and in doing so it becomes a more organic and contextual construct. In contrast to the clock-time of the objective perspective, this subjective perspective is often presented as event-time (Jacques, 1982).

The clock-time/event-time opposition is not the only contrasting temporal perspective evident within the organisational studies literature that has a bearing on issues of innovation speed. A second temporal distinction concerns that between the pacing of events driven by circumstances internal to the organisation and the pacing that pertains in its external environment (Brown and Eisenhardt, 1997). The very rhetoric of the contemporary imperative for speed (e.g. Stalk, 1988) provides the impetus for organisations to out-pace and stay ahead of their competitors. The alternative perspective argues that organisations cannot effectively set the pace of progress independent of the rhythms that pertain in their external organisation (Ancona and Chong, 1996). The time and organisations literature has included a strong thread of research related to the concept of entrainment (Bluehorn and Denhardt, 1988; Ancona and Chong, 1996). The concept is borrowed from natural science where it is used to explain the connection between an organism's internal and external biological cycles. In a social science setting it is "a process that integrates temporally differentiated activities and behaviours" (Bluehorn and Denhardt, 1988: 313). In relation to issues

of innovation speed, the implication is that the rhythm of markets (external pacing) is something to which an organisation's innovation efforts (internal pacing) should align, rather than simply out-pace.

A third temporal distinction in organisational studies is that between linear and cyclic time. Cunha (2004) characterises firms adopting a linear orientation as preferring to create their own future rather than simply relying on past experiences to guide their decisions. By contrast cyclical notions of time draw attention to patterns of reoccurrence in organisational life. Such notions are related to event-based time discussed earlier, but foreground the characteristic of the cyclical nature of such events. Cunha (2004) argues that firms adopted a cyclical orientation toward time are those that believe the past is a sure guide for action in the future. It is important to note that a linear temporal orientation does not simply relate to a view of innovation as proceed through orderly steps (i.e. it does not relate to linear innovation processes).

The three temporal dichotomies outlined here (clock/event, internal/external, and linear/cyclic) are themselves interrelated, but each dichotomy has specific temporal resonances, and draws attention to a particular temporal challenge faced by organisations. In the case of innovation projects these temporal challenges might be expressed in the following terms:

- Clock vs Event challenges: should the time allowed for innovation tasks be set to a defined timetable, or be defined by innovation actors following their subjective assessment of progress?

- Internal vs External challenges: should the pacing of projects align with related processes internal to the firm, or with the rhythms of external forces (markets, customers and competitors)?
- Linear vs Cyclical challenges: should past experiences guide decisions on what innovation task to do next, or should new possibilities be pursued?

The speed with which an innovation project is progressed from idea to launch will depend on the resolutions adopted to each of these questions. It seems unlikely that there could be a single answer to each question. The dynamic and creative nature of innovation projects might be expected to yield different approaches at different stages during the project (Eling et al., 2013). Furthermore, we suggest that tensions caused by innovation actors holding different temporal orientations are a source of slowness in innovation work that has not been addressed in this literature. In its reliance on quantitative studies of antecedents, the extant literature reviews on innovation speed privilege an objective notion of time. The extant reviews' advocacy of quantitative studies and rejection of qualitative studies reinforce an objective temporal orientation. Our brief introduction to different perspectives of time within organisational life suggests a more nuanced approach may be needed to fully conceptualise innovation speed. The organisation of innovation tasks in order to achieve accelerated outcomes requires some, or all, of these temporal challenges to be overcome. In developing our working theory of innovation speed the next sub-section explains the nature of these temporal challenges, and the requirements of a managerial intervention that seeks to overcome them.

Temporal challenges for organising

In an examination of how time has been portrayed within organisations Hassard argues that there are three time-related problems that all organisations must resolve (1996). The first temporal challenge for organisations noted by Hassard is the problem of "temporal uncertainty" (1996: 338). By this he means that organisations need to understand and attempt to manage the consequence of operational uncertainties for the timing of activities. In the context of the innovation speed literature such uncertainties would include those of technological developments (Song and Montoya-Weiss, 2001) and environmental uncertainty (Milliken, 1987). Hassard explains that solving this temporal challenge creates a need for "time schedules", i.e. "for reliable predictions of the points at which specific actions will occur" (Hassard, 1996: 338). Cunha (2004) views this challenge as being related to the dichotomy of clock-time/event-time, and different strategies for addressing this problem can imply different temporal conceptions for organizing work. One response is to set calendar-based new product launch deadlines (Brown and Eisenhardt, 1997) in order to try to shape the competitive environment. Alternatively having a more heterogeneous sense of time (i.e. event-time) might provide organisations with a greater variety of "chronological repertoires" (Clark, 1985: 137) with which to respond to a turbulent environment. We argue that in responding to the temporal challenge of uncertainty (Hassard, 1996), a conceptual model is needed of innovation speed that explains the pursuit of both clock-time and event-time strategies, and the choices organisations make between them.

Hassard's second challenge concerns the resolution of conflicts over temporal activities. He charaterises this as an issue of "synchronisation", i.e. "for temporal

coordination among functionally segmented parts and activities" (Hassard, 1996: 338). This coordination is not simply between different individuals and tasks, but also concerns the alignment of the pace of different processes. Cunha (2004) argues that this challenge can be understood in relation to the temporal opposition between internal time/external time. Solving the synchronisation challenge is a matter of aligning the rhythms of two organizationally-distinct activities or processes. Other temporal studies of organisations have argued that simply 'going faster' within a focal firm may ultimately proved futile, if that organisation's pace is not aligned with the rhythm of its external environment (Ancona and Chong, 1996). In addressing the temporal challenge of conflict over activities, we argue that a conceptual model of innovation speed should explain how organisations synchronise internal and external rhythms that set the pace for innovation.

Hassard's third temporal challenge concerns the scarcity of time (i.e. a given segment of time cannot be consumed or experienced twice or more), and the importance for optimally allocating resources to activities to ensure that they "will consume it [time] in the most efficient and rational way" (Hassard, 1996: 338). The organisational challenge is one of deciding what is the most valuable activity to be doing at any given point in time. Cunha (2004) expresses this choice in terms of the dichotomy between linear and cyclic time, and the way in which organisations approach the planning of projects. He argues (2004) that the linear-progression view is suggestive of organisations that believe that their environment is in such a state of constant change that they cannot rely on past experiences to guide future actions. By contrast organisations adopting a cyclical-time orientation maintain that previous experience will be a sure guide to future actions. We might reasonably expect that most

innovating organisations adopt a position between these two extremes. Solving the temporal challenge of allocation thus becomes one of deciding how to make use of learning from experience whilst remaining flexible enough to try new organisational practices.

Development of research questions to guide the literature review

We now draw together the threads of this discussion to construct our 'working theory' or framework to guide our literature review. Our approach has been to understand the temporal challenges faced by organisations for these issues must, in part or in whole, be solved if innovations are to progress speedily from idea to launch. Therefore, we posit that the three temporal problems elaborated in this subsection constitute a generalisable class of contexts (C) to which specific contexts of innovation speed may be resolved. In other words categorizing innovation speed studies in terms of the temporal challenges allows us to focus on the speed-related challenge within those studies rather than possible generic contexts related to innovation (e.g. technologies, markets or sectors). In our reading of the literature on innovation speed we evaluated which of these three generalisable contexts or temporal challenges (one, two or all three) each reviewed paper was concerned.

In seeking the interventions (I) to solve these temporal challenges, we started by considering the acceleration techniques of the type summarised in Table 1. However, our reading of the literature sought to go beneath these labels and identify the actual organisational activities that constitute them. Our aim was not to confirm (for example) that leaders are important antecedents for innovation speed (for that has

been established in the extant reviews), but to determine what leaders do to contribute to accelerate project outcomes.

Our approach has two requirements for any explanation of the mechanism (M) of innovation speed: (i) to explain how any individual intervention operates in order to accelerate innovation; and (ii) to explain how temporal dichotomies are resolved without an adverse impact on speed. We drew on the writing of Hassard (1996) to specify the type of solution for each temporal challenge, and we drew on Cunha (2004) to identify the temporal dichotomy associated with each challenge. Our "working theory" is thus expressed in terms of three generalisable contexts:

- Contexts of temporal uncertainty relate to the timing of innovation activities for the realization of accelerated outcomes. Within this context, we posit that speed is realised by scheduling interventions that: (i) ensure the most efficient and effective time for a specific innovation activity; and (ii) avoid delays caused by differences in temporal orientation (clock vs event).
- Contexts of temporal conflict relate to aligning the pace of different innovation activities for the realization of accelerated outcomes. Within this context, we posit that speed is realised by synchronisation interventions that: (i) ensure the most efficient and effective alignment of interactions between innovation actors and processes; and (ii) avoiding delays caused by a misalignment of internal and external pacing of innovation.
- Contexts of temporal scarcity relate to identifying the most valuable innovation activities to be conducting at any point for the realization of accelerated outcomes. Within this context, we posit that speed is realised by

resource allocation interventions that: (i) identify the most valuable tasks to conduct at any point in time; and (ii) being able to integrate past experiences with future possibilities.

These ideas (categories) are summarised in Table 2 in terms of temporal categories and their associated literature review questions.

Table 2 – Framework to guide synthesis of literature.

Temporal Categories			**Questions Guiding Literature Review**		
Temporal Challenge	**Temporal Dichotomies**	**Solutions for temporal challenge**	**CONTEXT**	**INTERVENTION**	**GENERATIVE MECHANISM**
Reducing temporal uncertainty	Clock time Vs Event Time	Scheduling	What aspects of the study are concerned with temporal uncertainty?	What are the scheduling practices? What temporal orientation do they reveal (clock or event)?	What are the generative mechanisms that address clock-time & event-time perspectives?
Reducing temporal conflict	Internal pacing Vs external pacing	Synchronisation	What aspects of the study are concerned with temporal conflict over activities?	What are the synchronisation practices? What temporal orientation do they reveal (internal or external)?	What are the generative mechanisms that are responsive to internal & external pacing?
Allocating resources amidst temporal scarcity	Linear progression Vs Cyclical Progression	Allocation of resources	What aspects of the study are concerned with temporal scarcity?	What are the resource allocation practices? What temporal orientation do they reveal (cyclic or linear)?	What are the generative mechanisms that allow transitions between past, present & future (cyclic & linear time)?

Methodology

In this paper we adopt a theory-led approach to the synthesis of the literature. In this we have been guided by the realist philosophy of systematic review (Pawson et al., 2005), as it has been developed for management and organisation studies by Denyer and Tranfeld (2009). These authors identified four principles for systematic review that we have tried to follow: transparency; explanatory; inclusivity; and heuristic. This review is transparent to the extent that we followed (and describe here) a defined methodology, and that we present (available as supplementary material) a summary of our (coding) analysis of the literature. Our principle aim in this review is to provide an explanation of innovation speed in temporal terms that are new to this literature. Our selection of literature is inclusive of studies using both quantitative and qualitative research methodologies. The output of this review is heuristic in the sense of providing a guide to inform practitioners on the selection of managerial interventions for speed.

The systematic review/realist synthesis method developed by Denyer et al. (2008) proceeds through three main stages:

1. The creation of an initial theory or framework for understanding the area of study. The conceptualization of innovation speed developed in the first half of the paper constitutes the framework (summarised in Table 2) that has guided our synthesis of the literature.

2. Conducting a literature search (Tranfield et al., 2003) and selecting articles that are "fit for [the] purpose" (Boaz and Ashby, 2003) for testing and refining

the initial theory.

3. The initial framework is developed in light of our reading of selected papers. In research terms, such a realist synthesis does not attempt to show the universal effect of a particular innovation speed intervention, but through an iterative process of reading and comparison with the initial framework, unveil the generative mechanisms.

At the outset of this review we convened a panel comprising senior business school academics in order to critique the progress of the work. Academics were selected with (a) an interest and background in innovation research, and (b) a track record of designing and publishing literature reviews in management journals. In consultation with the review panel we identified the relevant business and management bibliographic databases, database domains/topics/subjects and search keywords. The following search strings, designed to capture relevant papers:

(1) innov* AND (fast OR speed OR time OR accelerat*)

(2) innov* AND (disrupt* OR rapid OR stage-gate OR portfolio OR radical OR phase)

(3) (NPD OR new product) AND (fast OR speed OR time OR accelerat*)

(4) (NPD OR new product) AND (disrupt* OR rapid OR stage-gate OR portfolio OR radical OR phase)

We applied the search strategy to the chosen bibliographic databases of: Web of Science, EBSCO, Science Direct and ABI Global. The date range for returned papers was restricted to the years 1990-2015 to reflect the emergence of the interest in innovation speed in general (Blackburn, 1991; Starr, 1992). This initial search strategy generated a long list of 2,303 papers. The selection of studies for the next phase was undertaken by subjecting each paper to a series of criteria, with reasons for inclusion and exclusion being noted (we use the word 'filter' to label these different rounds of exclusion).

Having removed duplicates from the list, all titles were read to confirm they were in our broad area of interest (Filter 1). This allowed many papers to be dropped largely because they related to non-management topics (e.g. they were engineering papers). The abstracts of remaining 640 papers were read and those discarded that did not deal with decreasing the project time from idea-to-launch (Filter 2): leaving 292 papers. The next stage (Filter 3) involved a reading of the full paper to identify those that not only reported empirical research, but also offered detailed descriptions or explanations of managerial interventions for innovation speed (giving a total of 58 papers). The papers selected included findings (or discussion of findings) that described or explained managerial interventions for speed. We found such information on interventions in quantitative studies that included some element of qualitative data, or in purely quantitative studies that involved fine-grained constructs. Good qualitative research was amongst the studies selected; with the papers rejected often being purely anecdotal accounts of practice, rather than ones resulting from scientific study. To further clarify this selection criterion, consider the commonly studied antecedent of "cross-functional teams". We found many studies that sought to

test the hypothesis that using cross-functional teams leads to accelerated innovation outcomes. Notwithstanding the importance of this finding, not all of these papers elaborated upon establishing a positive correlation, by including details of what the cross-functional teams within their study had actually done (i.e. the interventions of cross-functional teams). Such studies show that having a cross-functional team was better (for speed) than not having one. We removed such studies from our review which rather sought detailed information on interventions, and the insights they offer on mechanisms to progress innovation more quickly.

Reading the selected 58 papers made evident the limitations of the initial bibliographic search strings (cf. Pittaway et al., 2004: 139). Hence a final phase of snowballing (Filter 4) was included, and examining the bibliographies of the full papers identified additional papers. These snowball returns were then checked by repeating Filters 2 & 3 to create a final total 71 papers to be included in the next stage of the review. This total was composed of 65 original papers and 6 literature reviews (discussed above). A summary of this selection method and associated exclusion criteria is presented in Table 3. A detailed summary of the 65 selected original papers, and the findings that we extracted from them are provided as supplementary data for this paper.

Table 3 – Summary of criteria for selection of studies for review

Filter	Method	Reasons for Exclusion	Papers remaining
0	Bibliographic searches	Original "long list" of papers	2,303
1	Reading of title	Does paper address the review questions? **Exclusions:** • Not a management or organisational studies discipline • Technical or engineering papers • Concerns another area of management (and not innovation) • Not written in English	640
2	Reading of Abstract	Does the paper concern improving the time from idea to launch? **Exclusions:** • Concerned with innovation adoption • General performance management papers • Related to novelty not speed • Concerned with other aspect of innovation: e.g. Ambidexterity, open innovation, paradoxes of innovation • Speed is an independent variable in a study of some other aspect of innovation performance • Proximal discipline (e.g. corporate venturing), but not addressing our review questions	292
3	Reading of Full Paper	Do the papers offer a detailed description or explanation based upon empirical research of how speed might be managed within innovation projects? Is the paper a literature review of this topic? **Exclusions:** • Same as Filter 2 • Scant original data provided on innovation practices (including hypothesis testing studies that only report correlation and offer no insight into how antecedents are enacted in practice)	58
4	Snowballing	Snowballing of bibliographies of the working list of papers. Repeating Filters 2 & 3	71

Management interventions and generative mechanisms for innovation speed

This section describes our reading of the innovation speed literature in the terms set out in the framework in Table 2. The explanations of the generative mechanisms underpinning managerial interventions for innovation speed are structured in relation to the three "temporal challenges", and their associated "temporal dichotomies" and "solutions for temporal challenge" (Table 2). A detailed summary of our coding of each individual paper to particular temporal categories is available as supplementary material. An overview of the interventions and mechanisms we identified associated with each temporal category is presented in Table 4.

Table 4 – Summary of interventions and generative mechanisms by temporal category

Generalisable Context	Temporal Uncertainty	
	Clock time	**Event time**
Scheduling Interventions	Articulate well-defined product vision	
	Set clear goals & milestones	Set flexible project milestones
	Adopt standardised routines and phase-gate processes	Allow teams to improvise necessary innovation activities
	Define schedule for product and market testing	Use technologies to communicate & compare different perspectives on progress (includes co-location)
Generative Mechanism	The determination to realise defined time-related goals.	The interchange of perspectives on progress in order to reduce uncertainty and to test improvised changes to plans.
Generalisable Context	**Temporal Conflict**	
	Internal pacing	**External pacing**
Synchronisation Interventions	Design concurrent engineering of internal processes	Work with customers and suppliers during development stages
	Coordinate different functional strategies	Generate prototypes, and release of acceptable products
	Share information in timely manner	Gather information related to external pace of change (e.g. roadmapping & benchmarking)
Generative Mechanism	The 'compression' of the time allowed to accomplish innovation tasks within the firm.	The responding to the pace and direction of the external environment.
Generalisable Context	**Temporal Scarcity**	
	Linear progression	**Cyclic progression**
Allocation Interventions	Leveraging expertise that is completely new to the firm	Ensure npd teams are stable and have dedicated members
	Recruit people with a wide breadth of experience	Have systems for capturing and making available learning from previous projects
		Key decisions based upon knowledge and experience within the organisation
Generative Mechanism	The exploration of innovation work unconstrained by firm's own experience in order to progress new ideas more quickly	The exploitation of past experience in order to save time by the avoidance of known issues.

Innovation Speed in contexts of temporal uncertainty

Contexts of temporal uncertainty draw attention to be importance of the timing of innovation activities for the realization of accelerated outcomes. Following the terminology of Hassard (1996: 338) we identified "scheduling" interventions; that is organisational activity related to the timing of specific actions. Furthermore, we categorised such interventions in terms of whether they suggested a "clock-based" or "event-based" temporal orientation. Within this context, we posit that speed is realised by: (1) the determination of the most efficient and effective time for a

specific innovation activity; and (2) avoiding delays caused by differences in temporal orientation (clock vs event).

Not surprisingly we encountered a number of studies that advocated clear clock-based management interventions. These approaches may start with a clear definition of the innovative product concept (Kessler and Chakrabarti, 1999; Minderhoud and Fraser, 2005; Tessarolo, 2007). Such well-defined end-points are then broken down into clear goals and milestones that are then used to drive the speed of projects (Swink, 2003; Allocca and Kessler, 2006; LaBahn et al., 1996). Some studies argued that this is important from the very outset of projects (Filippini et al., 2004; Kach et al., 2012). An important theme for such milestones was a schedule for the regular testing of products or prototypes with customers (Bers et al., 2009; Cooper and Kleinschmidt, 1994; Eisenhardt and Tabrizi, 1995; Minderhoud and Fraser, 2005). The setting of goals was suggested by some authors as something that should involve senior management (Carbonell and Rodriguez-Escudero, 2009), though once project goals were agreed further "tinkering" from top management should be avoided (Lynn et al., 1999; Mabert et al., 1992). Indeed Dougherty et al. (2013) went so far as to suggest that clock-time pacing of projects should be limited to strategic milestones only.

Allied to clarity in goals and milestones was the design of associated development processes. Different approaches were advocated with respect to process design. Prasnikar and Skerlj (2006) argued that clarity of key temporal targets (e.g. product registration timeline) should be allied to simplified development processes, whereas Minderhould and Fraser (2005) advocated detailed phase-gate processes. However, in recognition of the complexity of many new product development projects

Vassilakis (1997) suggested problem definition practices including: an ordering of decisions; specifying design goals; and minimizing sub-problem size.

In addition to studies that emphasised the orderly planning of innovation projects, many studies suggested that not all innovation projects could be so easily scheduled. Such studies speak to a more event-based orientation towards time (though this terminology was not used in the papers themselves). A recurrent theme saw project teams being given the freedom, within the context of defined project goals and defined processes, to improvise (Akgun and Lynn, 2002a; Akgun and Lynn, 2002b), take key decisions on how to conduct development steps (Lewis et al., 2002; Sarin and McDermott, 2003; Naveh, 2007) or even be allowed to miss out steps (Lynn et al., 1999). Some studies noted that such flexibility in deciding how plans were executed could be manifest as non-rigid goals (Allocca and Kessler, 2006).

An important feature of such event-based interventions was the comparison of different perspectives on progress. This could be from bringing people into contact who were of different levels of seniority within the organisation (Terziovski et al., 2002), or from different disciplinary backgrounds (Iansiti, 1995). This could involve the co-locating of members at stages requiring sense making of complex information (Kessler and Chakrabarti, 1999; Carbonell and Rodriguez, 2006). However Ettlie (2007) found the use of virtual teaming software enabled asynchronous comparison of progress, which in turn meant fewer formal review meetings.

In summary, clock-based interventions are ones that emphasise clarity of action: what is to be done and when is it to be completed. The generative mechanism for

innovative speed is then the determination to realise goals. This is the "acceleration intermediary of motivation" expressed by Zirger and Hartley (1994: 243). Event-based interventions by contrast are ones that allow flexibility in decisions about action; including (crucially for speed) decisions about timing and duration. Here the generative mechanism is the interchange of perspectives on progress within projects. In part this mechanism is covered by Zirger and Hartley's "acceleration intermediary of project complexity" (1994: 236). Those authors emphasise the reduction in the complexity and uncertainty within innovation projects, to which we would add the responsibility to improvise action.

What remains unanswered in the extant literature is the mechanism by which the two temporal orientations are integrated within the same innovation project. Some authors may imply that both temporal orientations can exist comfortably side-by-side within projects. The suggestion is that strict milestones are set by managers, and team members are allowed the flexibility to act within these defined timings (e.g. LaBahn et al., 1996). More recently, Chen et al. have demonstrated a curvilinear relationship between team autonomy and speed (2015), and identified high environmental turbulence as the key contextual feature that justifies managerial interventions in the work of NPD teams. Our presentation of the coding of the literature in Table 4 highlights these apparent contradictions, e.g. clear milestone vs. flexible milestone, stage-gate vs. improvisation. Importantly, and as noted in the case study of innovation in the Pharmaceutical sector by Dougherty et al. (2013), differences in temporal orientation is a cause of tension within projects, and failure to integrate these temporal perspectives is itself a source of slow projects. Our framework analysis in this literature review draws attention to this tension: how can a project both stick to

defined milestones and allow interpretation in what those milestones are? And yet changing circumstances may well necessitate shifts between clock-based and event-based interventions (cf. Chen et al., 2015). The generative mechanisms for such shifting are not explained within this literature. We suggest a way of conceptualizing such shifts in the Discussion section as part of a call for new research avenues for this literature.

Innovation Speed in contexts of temporal conflict

Contexts of temporal conflict draw attention to the importance of the aligning the pace of different innovation activities for the realization of accelerated outcomes. Following Hassard (1996) we used the label "synchronisation" for interventions related to such alignment. Furthermore, we categorised such interventions in terms of whether they suggested an "internal-based" or "external-based" temporal orientation. Within this context, we posit that speed is realised by: (1) the determination of the most efficient and effective alignment of interactions between innovation actors and processes; and (2) avoiding delays caused by a misalignment of internal and external pacing of innovation.

Beginning with internally-oriented management interventions then the realization of benefits (cost, quality and speed) as a result of the parallel execution of different disciplinary activities is very well established within the innovation literature in general (Gerwin and Barrowman, 2002). Such concurrent engineering of organisational process is a frequently advocated practice in this literature (e.g. Calantone et al., 1997; Eisenhardt and Tabrizi, 1995; Filippini et al., 2004; Griffin, 1997; Hauptman and Hirji, 1996; Mabert et al., 1992; Minderhoud and Fraser, 2005;

Zirger and Hartley, 1996). It is interesting that a number of authors in our review who have written in detail about this practice all conclude there is a "hierarchy of techniques" that must be mastered in turn (Millson et al., 1992; Nijssen et al., 1995; Sun and Zhao, 2010). The implication is that enacting concurrent engineering is not simply a matter of the efficient, parallel planning of tasks, but a capability that must be developed. In addition to time gains through the optimization of innovation processes, other forms of internal alignment were noted that promoted the timely sharing of information: the coordination of different functional strategies (Schoonhoven et al., 1990; Swink and Song, 2007); having common communication technology across different groups (Droge et al., 2000); and co-location of different functions (Mabert et al., 1992).

Turning to issues of perspectives on pace external to the focal organisation, then having an innovation team working closely with customers and suppliers is a common practice (Du et al., 2014; Langerak and Hultink, 2008; Mabert et al., 1992; Wonglimpiyarat, 2005; Karagozoglu and Brown, 1993). These studies invariably involved incremental innovation, or were employed in "manufacturing firms". In these cases the focal firm already knew customers, and the innovations were related to existing products. There was evidence of interactions continuing throughout the new product development process either formal meetings or informal communications as part of everyday business dealings. In situations in which the degree of technology development was more complex, then there appeared to be a corresponding increase in the sophistication of collecting market-related intelligence (Swink and Song, 2007; Wonglimpiyarat, 2005; Terziovski et al., 2002; Zirger and Hartley, 1996). Particular practices for monitoring the external environment included the use of "Roadmaps"

(Floricel and Miller, 2003), benchmarking exercises (Karagozoglu and Brown, 1993) and data mining tools to systematically collect and collate information (Bers et al., 2009). More direct forms of testing the pace of markets resulted from the evaluation of prototypes (O'Connor and DeMartino, 2006; Mabert et al., 1992) or the release of 'acceptable' products followed by rapid next generation improvements (Kessler and Chakrabarti, 1999).

However, regardless of the sophistication of the intelligence gathering system, the importance of having the internal capability of responding to external signals was paramount (Bers et al., 2009; Carbonell and Rodriguez Escudero, 2010; Rodriguez-Pinto et al., 2001). Many studies reported the responsibility for interpreting and acting upon external pacing signals lay in the work of cross-functional teams. Our categorisation of speed as requiring the synchronisation of internal with external pacing makes an additional requirement for explanations of speed. The coupling (e.g. Kessler and Chakrabarti, 1996: 1181) of disciplinary activities and inter-disciplinary communications provides a conduit for interpreting, resolving and responding to both internal and external pacing signals. In their study of the relationship between new product speed of development and new product success Chen et al. argued (2012) that different degrees of market newness called for different time based strategies; and that it could be disadvantageous to proceed too fast. Using the terms of the current review, new product success requires that an alignment of the pace customers can absorb product innovations (i.e external pacing) with the speed with which firms can produce new products (i.e. internal pacing). Chen et al. advocate an intervention of "probe, learn, iterate fast" (2012: 288). In our reading we suggest this capability includes learning how to interpret external pace-related signals (as well as those

related to product features) and integrate them into internal activities. Each "probe, learn, iterate" cycle then provides an opportunity to re-align internal and external pacing.

In summary, internal-based interventions are ones that emphasise the optimization of time taken to run innovation processes. The generative mechanism for innovative speed is then the compression of time to accomplish innovation tasks. This is part of Zirger and Hartley's "acceleration intermediary of project complexity" (1994: 239). External-based interventions involve engagement with supply chain partners, testing prototypes and gathering information related to the pace of market changes. Here the generative mechanism is responding to the pace and direction of the external environment (cf. McCarthy et al., 2010). The reduction of market uncertainties feature in Zirger and Hartley's construct of project complexity" (1994: 237). Those authors emphasise the time wasted in the search for information and in revising product designs. Whilst the entrainment of internal and external-based managerial interventions for speed has not been a feature of this literature, the periodic re-alignment of internal and external pacing may be accomplished through "probe, learn and fast iterate" interventions (Chen et al., 2012).

Innovation speed and temporal scarcity

Contexts of temporal scarcity draw attention to the importance of the identifying the most valuable innovation activities to be conducting at any point for the realization of accelerated outcomes. Following the terminology of Hassard (1996) we identified "allocation" interventions; that is organisational activity related to establishing what innovation tasks should be undertaken. Furthermore, we categorised such

interventions in terms of whether they suggested a "linear-progression" or "cyclic-progression" temporal orientation. Within this context, we posit that speed is realised by: (1) the identification of the most valuable tasks to conduct at any point in time; and (2) being able to integrate past experiences with future possibilities.

The organisational interventions that we encountered relating to temporal scarcity were dominated by the idea of leveraging past experience within the organisation to resolve issues in the present and future; thus suggesting a cyclic orientation towards time. These interventions involved (invariably) cross-functional teams in achieving accelerated innovation by drawing upon their learning from previous projects. In stable environments or in cases of only moderate levels of innovation then studies noted the advantage of: stability within NPD teams (Carbonell and Rodriguez, 2006; Akgun and Lynn, 2002a; Akgun and Lynn, 2002b); team members dedicated to individual projects (Cooper and Kleinschmidt, 1994); and running post-project reviews (Thomke and Fujimoto, 2000; Sherman et al., 2000). Akgun et al. conceptualise this process in terms of the creation of "transactive memory systems" (2002a; 2002b). They observed the creation and maintenance of information systems encompassing expertise and experience amongst people within the project's network. They found that communicating this to team members and allowing all access to the network, enables project actors to transcend different options for action within the current project.

As projects become more complex or involved significant technology change then the range of innovation actors on whose experience NPD teams drew, became more widespread and extended beyond the organisation itself; as did the organisational

practices to leverage their experience. Such interventions included: outsourcing systems development in a case of financial service innovation (Drew, 1995); linking Just-in-Time purchasing systems to supplier development goals (Droge et al., 2000); creating and participating in industry networks (Floricel and Miller, 2003); recruiting experienced executives to run start-up enterprises (Heirman and Clarysse, 2007); working with technology intermediaries (Knockaert and Spithoven, 2014); retaining the services of the academic inventor in the case of university spin-outs (Markman et al., 2005); and working with established suppliers as part of a market entry strategy (Prasnikar and Skerlj, 2006). Our interpretation of interventions to access new-to-the-firm knowledge and expertise is that they reveal a linear temporal orientation amongst innovation actors.

The mechanism for interventions with a cyclic temporal orientation relates to the learning resulting from past experiences. This is manifest as time saved in avoiding known issues (in the present or likely to occur in the future), or as an intuitive grasp of an issue that allowed expert decision-making. The only type of intervention we categorise as cyclic that found a place in Zirger and Hartley's mechanisms of speed was "dedicated team members" whose mechanism they explained with reference to their "acceleration intermediary of motivation" (Zirger and Hartley, 1994: 244). These authors argued that stable dedicated teams enabled project goal coherence. In the two decades since their seminal paper, the range and sophistication of interventions for drawing upon previous experience has increased.

The interventions we have categorised as displaying a linear orientation towards time involve organisations drawing upon a wider pool of experience in order to allocate

resources towards innovation activities. In this they are seeking to avoid being constrained by their own past. This suggests that such activity could be understood as a more generic set of interventions geared towards doing completely new (to the innovating organisation) things. The innovation literature in general emphasises breaking with the past, and dealing with discontinuities and disruptions. However progress in such circumstances has not been framed in terms of speed explicitly, but rather in terms of disruption (cf. Christensen, 1997) or radical change (cf. Henderson and Clark, 1990). Studies framed in terms of innovation speed seem more focused on exploitative new product development that can make use of a cyclical time orientation and much less on explorative technological searches that try to break with the past. From the wider innovation literature, studies of emerging technologies (Bhardway et al., 2006; Fleming and Sorenson, 2004) suggest pure explorative search occurs when both technology and market domains are new to a firm. These are broad technological domains potentially yielding a variety of market applications that may prove to be broad or narrow. Here innovation activity encounters a double challenge of developing competency in a new technology and creating, what are at best, elusive market applications. The wider innovation literature suggests searching in such distant domains is exceptional and is more likely if the acting firms and individuals are in possession of a breadth of experience in exploring distant domains (Dimov and Martin de Holan, 2010; Gavetti et al., 2005). By contrast, the "probe, learn, iterate" interventions within this literature (e.g. Chen et al., 2012; Costanzo, 2004) involve the search of near domains with known customers and supply-chain partners.

What remains unclear in this literature is the mechanistic question of how linear and cyclic temporal dichotomies are resolved in the pursuit of accelerated innovation.

This has not been a feature of this literature, and we take up this conceptual challenge and its implications for future research in the next section.

Discussion - resolution of temporal dichotomies and suggestions for future research

In the last section we argued that innovation actors holding different orientations towards time within a particular project could constitute a barrier to innovation speed. The existing literature adopts (implicitly) a single temporal orientation and the generative mechanisms we noted are unable to fully explain temporal dichotomies. In this section we suggest that future research in this area should seek to identify explanations for innovation that include resolving temporal dichotomies. To this end we identify theoretical concepts and methodological approaches capable of addressing each temporal dichotomy. We continue to structure our discussion in terms of the temporal categories in Table 2.

Clock-time and Event-time temporal dichotomy

We noted earlier an apparent assumption in this literature that innovation projects can be both subject to defined schedules and allow flexibility in the interpretation of those schedules. Biazzo (2009) critiques a comparable acceptance of a dichotomy between a flexible NPD processes and Stage-Gate processes. The recent paper by Dougherty et al. (2013) demonstrates that innovation actors holding different temporal perspectives on the timing of activities can be a source of slowness within innovation projects. We conclude that more research is needed to understand how the clock/event temporal dichotomy is resolved within innovation projects. Examining

the organisational studies literature on time suggests one explanation of how this dichotomy might be resolved is found in the notion of temporal structuring in organisations developed by Orlikowski and Yates (2002).

Orlikowski and Yates are interested in understanding time as an enacted phenomenon in organisations (2002). In this they examine how through their daily practices, organisational actors produce and reproduce temporal structures that "guide, orient, and co-ordinate ongoing activities" (Orlikowski and Yates, 2002: 684). Such structures include project plans, reporting schedules, seasonal events, open-ended project phases and contract periods. These structures are developed and used to set the pace of organisational work. However, in their adoption of a practice-based perspective, these authors argue that such temporal structures cannot be simply understood as some objective expression of external events, or organisational sensemaking. Rather, they posit that temporal structures are constituted in action, that is social practices not only generate such structures, but that the structures may be altered by the actions they influence. For example, the repeated use of certain temporal structures may reinforce their legitimacy for guiding action. "Temporal structures are [to be] understood as both shaping and being shaped by ongoing action" (2002: 684). This process of the production and re-production of temporal structures is labeled by the authors as temporal structuring. Their main insight (and key contribution to our thinking here) is that "time is realised [in organisational life] through people's recurrent practices that (re)produce temporal structures that are both the medium and outcome of those practices" (Orlikowski and Yates, 2002: 684). These authors argue further that such temporal structuring provides an approach to understanding how the dichotomy between clock-time and event-time is resolved.

Temporal structures, like all social structures are only ever provisional, and because they are created through recurrent practices, they can be change through such practices. This idea draws attention to the "temporal reflexivity" (Orlikowski and Yates, 2002: 698) of innovation actors as, working within a given temporal structure (say, an open ended project phase), they monitor their own action and switch their temporal orientation (to say a fixed deadline for the end of the project phase).

Following their practice-based conceptual framing of temporal challenges we suggest that research on innovation speed should produce more detailed accounts of what organisational actors actually do in order to produce and reproduce temporal structures to guide their activities. This advocacy of empirical research to uncover detailed case studies of innovation work is in line with other authors who have problematized the assumption that these different temporal orientations can be easily managed in innovation projects (Biazzo, 2009; Dougherty et al., 2013). This would include more longitudinal studies capable of delineating the shifts in emphasis of such interventions.

Internal-pacing vs External-pacing temporal dichotomy

Although the dichotomy between internal-pacing and external-pacing is not explicitly named in this literature, the extensive array of interventions studied under the label of concurrent engineering and stakeholder engagement means that this dichotomy has, at least partially, been addressed in this literature. In questioning whether speed is always a good thing for innovation Chen et al. explore customers' absorptive capacity for adopting new products, and the risk of fast NPD "overshooting customer needs (2012: 299). Their advocacy of a "probe, learn, iterate fast" intervention (Lynn et al.,

1996) is not only about fast prototyping of new technologies, but also testing the customer's absorptive capacity for the same. In the temporal terms we have used in this paper "Probe, test, iterate fast" involves a periodic realignment of internal-pacing and external-pacing of organisations.

The challenge associated with the periodic realignment of internal and external pace is greater when one considers the multi-dimensional nature of pace in the external environment of innovation firms. In developing a conceptualisation of "environmental velocity" McCarthy et al. argue (2010) that its multidimensional nature (entailing technology; product; demand; regulation; and competition) has been neglected in research. In relation to NPD they argue that "previous research has shown the value of rapid new product development in high velocity industries…but leaves open the question of how this might change if we incorporate a multi-dimensional conception of environmental velocity" (McCarthy et al., 2010: 619). There is a connection here with the widespread importance of cross-functional teams for innovation speed, as McCarthy et al. suggest different functions are "likely to be more effective when that function is entrained with the environmental dimension for which it is more directly responsible" (McCarthy et al., 2010: 619). Again this suggests the need for more fine-grained studies of innovation speed that include how the different functions in teams contribute to the periodic re-alignment of internal-pacing and (multi-dimensional) external-pacing.

In a related observation it is important to note that we did not encounter any instances in this literature of the idea of entrainment (Ancona and Chong, 1996) in which the pace of internal processes was 'naturally' attuned to associated external processes.

The practices noted above rather concern prompting or detecting signals from the external environment and then responding. Having internal and external systems attuned is not something we encountered in our reading. Rosenthal & Tatikonda did suggest (1992) that there could be an "NPD rhythm" to internal planning processing allied to critical external processes such as regulatory approval, but the nature of the entrainment mechanism was not made evident. In this regard, one of the few papers we found that related to service innovation might merit further consideration: Buganza & Verganti (1992: 368) argued that adapting rapidly to market changes was made easier if firms used open source technologies used widely in those same markets.

Linear progression vs Cyclic progression temporal dichotomy

The temporal dichotomy of linear progression vs cyclic progression concerns whether innovating firms in deciding what to do use resources that reside, in temporal terms, in the past or in the future. Disagreements in decisions over priorities of activities born of differences in linear/cyclic temporal orientations might be expected to lead to non-optimal resource allocation, with adverse consequences for speed of innovation. However, we suggest that resolving this linear and cyclic dichotomy cannot simply be a matter of integrating two temporal mindsets. In reporting our findings earlier we drew an analogy between the linear/cyclic temporal dichotomy, and wider innovation ideas concerning exploration/exploitation and near-search/far-search. As the wider innovation literature on such subjects has made evident, these opposites defy simple mechanistic integration. Rather, we suggest a resolution to the linear/cyclic dichotomy can be found through a mechanism of creating links in time between the past, present and future (cf. Brown and Eisenhardt, 1997). We posit that innovation

speed is served not simply by the absence of disagreement on the best (temporal) basis for resource allocation decisions, but also by drawing upon the possibilities suggested by experiences of the past and dreams of the future to serve resource allocation decisions in the present. Brown and Eisenhardt observed managers of successful product portfolios in the computer industry were able to make such links in time through "choreographed transitions" (1997: 29). A similar individual level of analysis was conducted more recently by Nadkarni and Chen in their study of the temporal focus of CEOs and the rate of new product introductions (2014). These authors concluded that the rate of new product introduction may be predicted by whether the CEO attends to the past, present and future. They also suggested that such a multi-dimensional conceptualisation of time should be an important element in studies of new product introduction (Nadkarni and Chen, 2014: 1826).

At the organisational-level of analysis considered in this review then a concept new to the innovation speed literature that could help in tracing such links in time is found in the work of Bartel and Garud on innovation narratives (2009). Bartel and Garud suggest that making such links in time when managing innovation involve the "simultaneous activation of memory and imagination" (2009: 114). Firms can develop a "transformative capacity" (Garud and Nayyar, 1994) to reactivate and synthesis previous innovation experiences to serve their current needs. And yet, given the complexity and uncertainty of innovation work (Van de Ven et al., 1999), such reactivation also needs to be able to generate new possibilities. Bartel and Garud invoke (2009) narratives as a vehicle that both preserves organisational memory (Walsh and Ungson, 1991) of past innovation, but does so in a manner that allows people in the present to generate new possibilities. They use the term narrative as

involving the detailed expression, with a beginning, middle and ending, of a series of events. The re-telling and re-interpretation of organizational narratives allow past experiences to be applied to new situations. In this manner "innovation narratives provide a means of coordinating the past, present and future" (Bartel and Garud, 2009: 114). Narrative research (Czarniawska, 1998) was not adopted in any of the literature we reviewed for this paper.

Suggestions for Future Research – Concluding Remarks

In the first major review of the innovation speed literature Kessler and Chakrabarti called for a "systematic testing of proposed relationships" to correct the confused picture of extant research at that time (Kessler and Chakrabarti, 1996: 1154). Since then hypothesis testing research involving quantitative data has dominated academic research in this area. With the meta-analysis of Chen et al. (2010) the findings of the best of these studies have been synthesized and the call issued by Kessler and Chakrabarti has received a comprehensive response. The subsequent validation of this work by a second independent meta-analysis (Cankurtaran et al., 2013) indicates a significant consensus concerning the antecedents of innovation speed. Therefore, we argue that the further development of this area now requires more rigorous qualitative research to widen our theoretical understanding of innovation speed. In being theory-led and working with both quantitative and qualitative data, this review has been consistent with this goal. In this discussion we have suggested a number of theoretical concepts and methodological approaches that could guide future studies that are rich in detail and that enable an understanding of how temporal challenges and particularly temporal dichotomies (Table 2) may be resolved.

Finally, we note that the innovation speed literature is dominated by evidence that relates to new product development. In our selected papers there was only two studies (Costanzo, 2004; Drew, 1995) that related to service innovation, and none to other types of innovation (e.g. process innovation or management innovation). Future research might explore how accelerated innovation is achieved in these arenas.

Implications for Practice

In addition to future academic research to address the substantive topic of this review, work is needed to develop its practitioner implications. The complex mix of antecedents, moderators and contingencies within this literature may create the impression of a long menu of possible managerial interventions for speed (cf. Table 1). Notable authors in this field counsel practitioners to be careful in their selection of such techniques. Langerak and Hultink write, "new product teams must carefully select which NPD acceleration approaches are useful to achieve their NPD objectives expressed in terms of speed" (Langerak and Hultink, 2005: 37). Chen et al. end their own literature review with this caution for practitioners, "Overall, because developing a new product is a systematic problem-solving process, managers should be cognizant of the need to balance opposing forces and integrate multiple factors" (Chen et al., 2010: 29). Our analysis of the literature highlights (cf. Table 4) the apparent contradictory advice of individual studies. However, by drawing attention to generic underlying temporal challenges within organisations, our review may help practitioners in the selection and balancing of different acceleration techniques.

Limitations of Review Method

In addressing the possible weaknesses of our review we adopt the argument that such matters should be assessed in relation to the quality of the review itself (Briner and Denyer, 2012). In making our method transparent in this paper and its supplementary material, we have sought to answer the quality criteria listed by the same authors (ibid., p126). In following the emerging models of systematic reviews in management studies we have sought to justify a selection of literature that is "fit for purpose" (Boaz and Ashby, 2003). However a certain amount of researcher subjectivity is inevitable. In this we note that the interpretive judgment of the reviewer in the process of synthesis is actually integral to the realist approach (Pawson, 2013).

Concluding Remarks

The principal contribution of this review is to offer a new conceptual perspective on the complex empirical research examining how innovation projects may be accelerated from original idea to launch. By drawing upon wider scholarship relating to time and organisations we have: (1) developed a theoretical framework for synthesizing the innovation speed literature based upon a CIMO architecture; (2) extended established (Zirger and Hartley, 1994) explanations of innovation speed mechanisms by arguing the importance of resolving temporal dichotomies in innovation work; (3) identified new avenues of research to further enrich our theoretical understanding of innovation speed; and (4) developed a framework that may guide innovation practitioners in their selection and execution of the large array of acceleration techniques evident in this literature. A secondary contribution of this relates to our review methodology. Examples of theory-led realist syntheses of the

management research literature are rare (Pawson et al., 2005). We hope this example stimulates more interest in this, and other explanatory forms of research synthesis (Denyer et al., 2008)[1].

Notes

1. Researchers interested in realist synthesis will find resources related to this method at the websites of the Evidence Network (http://www.theevidencenetwork.com), The EPPI Centre (http://eppi.ioe.ac.uk/cms/) and The Campbell Collaboration (http://www.campbellcollaboration.org).

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